



Dialogues with AI: the power of “weight” in the mechanics and dynamics of high-speed trains

Dialogues with AI: the power of «weigh»

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Abstract

The most famous, common, but incorrect definition of the force “weight” is as follows: “Weight” is the force of interaction of a body with a support, caused by the force of gravity and directed vertically downward. This definition is used by artificial intelligence, models GPT-3.5 and GPT-4o. From the definition it follows that “weight” is only a load on the support. For example, a railway train loads the rails. This definition is supported by transport specialists, it is enshrined in textbooks, technical documentation and state regulatory documents. But in fact “weight” is an active driving force that completely determines the movement of a body along the support, describes its characteristics. “Weight” is the force of the double interaction of two bodies, which can arise under the influence of various factors, is not limited to the force of gravity. This is the author’s point of view. It is supported by physicists, scientists of theoretical mechanics (some). However, they avoid providing a

definition of “weight”. The article is presented in the form of dialogues with artificial intelligence, in which the laws of interaction of material bodies are studied. The GRT-4o model initially quite confidently adhered to this generally accepted definition. Analyzing the action of "weight" together with the author, performing calculations and correcting errors, the AI step by step abandoned the incorrect definition. The article describes the communication methods and learning results. The understanding of the concept of "weight" is clarified, it is shown that "weight" is a complex force that combines a number of components. "Weight" fully determines the movement of the body along the support, corresponds to the definition of a generalized force, it should be used when compiling the equation of motion using the methods of classical mechanics, for example, using the Lagrange equation of the second kind

Keywords: Weight 1; Body-support interaction 2; Motion dynamics 3; Artificial intelligence 4; Electric traction 5; Generalized force 6; Lagrangian mechanics 7.

1. Introduction

The essence of the problem is to determine the force of “weight”, its role in the dynamics of the movement of bodies, vehicles on a highway or railway track. The main question is what kind of force is this? What is its role in the complex system of operation of vehicles, the organization of road traffic, the regulation of the characteristics of vehicle movement? How much attention should be paid to it? It is widely believed that “weight” is a passive force that only creates a load on a road or railway track. It can be represented, for example, as an inactive mass multiplied by a certain number 9.82, source ^[1], or represented as a gravitational force directed vertically downward, as AI does, and no longer pay attention to it. From its numerical value, only the friction force that impedes movement can be calculated. This force will not provide anything useful. This is the dominant point of view, it is fixed in school textbooks, monographs of scientists in technical sciences, documentation in the field of transport, and therefore "weight" is not of interest to the readers of the journal, there is no need to publish an article about it. This point of view was held by artificial intelligence; it is recorded in a large amount of technical literature.

Another point of view, which differs from this one, and which the author tries to convey to the readers, follows from the fact that "weight" is an active, dynamic, complex force. This force, acting on the vehicle, sets it in motion and determines the main characteristics of the movement. It changes over time, depends on the characteristics of the road and vehicles, on the engine operating modes and reflects the control actions of the traffic control system. Automatic, computerized vehicle control systems work effectively when the "weight" force is selected during the calculation of the movement. Taking into account the features of the "weight" force is an important point in the design and production of vehicles and their operation. When training specialists, the force of "weight" should be given maximum attention. The problem of the force of "weight" has a number of aspects.

- It is necessary to develop a definition of the force of "weight", which most accurately and fully reflects its essence.
- To achieve a correct explanation of this force in various sources of information.
- • To find out how this force acts in various road conditions.
- To consider the formation of the force of "weight" from its sources, and how they have a single force called "weight".
- To study the characteristics of "weight" and their manifestation in various road conditions.
- To practice using "weight" when calculating electric traction: the movement of vehicles as a whole, the interaction of their components during movement, energy consumption for movement.
- To study the change in "weight" depending on the characteristics of the road, road sickness, operating modes of traction engines and the traffic control system.
- To develop a traffic control system based on the formation of the force of "weight".
- Change the teaching of physics in schools and applied technical disciplines in universities to accurately reflect the physical processes of the interaction of the body and the support, the emergence of the force of "weight" as a result of this interaction.

2. Data and methods

2.1. Analysis of the emergence of the problem and the current state of the definition and use of the force "weight"

The basic principles of calculating the dynamics of trains and electric vehicles were laid down in the late 19th and early 20th centuries. These calculations are based on taking into account the forces acting on a unit of weight of the vehicle. The calculations were reduced to a unit of mass. They were used to evaluate the characteristics of vehicles of different masses, namely: energy consumption, the amount of transport work performed, and movement schedules. These calculations were carried out in the ICGSS system of measurement units, where the main unit was weight, and mass was considered a derivative of it. The dynamics of movement were calculated by sequentially changing the speed of movement in three modes: initial acceleration to maximum speed, the subsequent coasting mode, and the braking mode. Examples and details of the calculations are given in the sources ^[2-4]. At the beginning of the 20th century, differential equations began to be used for calculations ^[4,5]. Similarly, for a train of unit mass, where the acting forces are divided by weight, dynamics equations were compiled. The dynamics equation for the entire route included the sum of equations for individual sections of different track profile slopes. Curved sections were replaced by straight lines with an equivalent slope relative to the resistance forces on the curves. The solutions of the sequence of equations were combined and the equations of motion along the entire route were obtained in the form of velocity graphs. The solutions of the sequence of equations were combined and the equations of motion along the entire route were obtained in the form of velocity graphs. This calculation method is still used today in accordance with regulatory document ^[1].

The normative document ^[1] "Rules for calculating traction for train movement" was developed in 1980 by the USSR Ministry of Railways with the aim of switching to the international system of SI units. However, this gave rise to a number of scientific problems in the field of traction calculations. In the document, the force "weight" is taken to be equal to the mass in tons multiplied by 9.82. The author ^[6] explains this replacement by the negative consequences of the transition to SI, which he considers to be the need to change existing calculations and correct a large number of technical documentation and reference literature, textbooks, etc. At that time, replacing the concepts adopted in the document almost did not require such changes. It was only necessary to slightly adjust the text, return to the concepts

of the ICGSS systems, where the basic unit of force was the kilogram, take the kilogram of mass instead, multiply it by 9.82 and call it “kinewton of train weight”. The force was replaced by mass without taking into account the fact that these are different physical quantities. If before that the calculations were performed in the ICGSS system and were physically correct, then after such a transition to SI, confusion of concepts arose. A number of problems arose, starting from the educational process, the explanation of the acting forces - the causes of motion and mass - the measure of inertia of the motion of bodies. The problem of the dimensionality of physical quantities has arisen. The question of this article, where "weight" is considered an active force that determines the dynamics of motion, is impossible in such a situation.

- According to this document, the units of measurement of two incompatible systems are used: - ICGSS and SI, which is unacceptable.
- The accepted definition of "weight" contradicts the scientific definition. Neither the direction of the "weight" vector nor its change during motion is taken into account.
- Units of measurement are used that are not accepted by any meteorological system.
- Due to this definition of the acting forces, the equation of motion is written in dimensionless units.
- When changing the dimension of any quantity, the equation has a different form. A table of numerical coefficients of dimension is necessarily added to it. This practice is typical for all textbooks and monographs developed in accordance with ^[1], for example ^[7-12] and dozens of others. This causes numerous errors that are made even by authors of university textbooks, for example ^[8].
- All textbooks published before the adoption of document ^[1], in which the theory of electric traction is presented correctly from the point of view of compliance with the ICGSS system of units, have been withdrawn from use ^[4] or corrected, for example ^[12].
- The calculation rules given in document ^[1] cannot provide calculations of the dynamics of high-speed trains and other vehicles, since “weight” is not a constant, is not an analogue of mass. In fact, “weight” changes during movement both in direction and in numerical value. “Weight” is the main driving force that determines the dynamics of movement, and its incorrect definition cannot lead to correct calculation results.

The difficulties presented here are associated with the use of an incorrect definition of the concept of “weight” and a misunderstanding of the influence of this force on the dynamics of movement of vehicles. This situation requires a detailed study of the interaction of the vehicle with the road, the influence of the force "weight" on the dynamics of the vehicle's movement, revision and organization of existing documents and correction of textbooks. The problem concerns not only electric transport, but also other technical disciplines in which incorrect definitions of the force "weight" are used.

A separate issue concerns the correct definition and use of the force "weight" as a complex force, and not as separate forces, such as centrifugal force and gravity, which are often considered as independent forces. In calculations performed using GPT-4o, this approach led to errors, incorrect results, which are discussed below.

2.2. Sources of information, according to the objectives of the study

2.2.1. Definition of the concept of "weight" in a historical aspect

The term "weight" was used in technical and scientific sources until the beginning of the 17th century. The emergence and development of the concept of "weight" are given in historical review sources ^[13-15], which show the evolution of the understanding of "weight" from the point of view of the development of science. In the Middle Ages, "weight" was considered as the force of gravity and at the same time as a measure of the amount of matter. Newton in his work "Mathematical Principles of Natural Philosophy" ^[13] distinguished between the concepts of mass and "weight". He introduced the concept of mass, which measures the inertia of a body and the amount of matter in gravitational interaction. The concept of "weight" lost the meaning of the amount of matter. Newton clarified the physical term force and explained its understanding as the result of the pairwise interaction of two bodies ^[13]. "Weight", as the force of interaction of a body with support, has two components associated with both bodies. One component applied to the support is called the “weight”, the other, applied to the second body, is called the reaction to the “weight”. Along with this force, other forces can be considered, for example, the force of gravity, but the force of gravity characterizes only the interaction of the body with the Earth. “Weight”, as a force of interaction, is much more complex, it can include other forces, for example, centrifugal, the force of elasticity of the rail, the forces of molecular, magnetic and electromagnetic interaction. It is also important to consider that the movement of heavy freight vehicles along the support (railway or highway) is ensured by the “weight” itself, and not by its individual components. Considering the individual components

of “weight” independently leads to errors, as, for example, when considering circus tricks in the circus arena, described below.

2.2.2. Traditional definition of “weight”

“Weight” was usually defined as the force with which a body acts on the Earth (or other celestial body). In most modern textbooks, such as ^[16-20], “weight” is explained through the force of gravity. But the action of a body on the Earth is not consistent with the concept of gravity. There is also centrifugal acceleration – an inertial force directed from the center of the Earth at the equator and perpendicular to the Earth’s axis at different latitudes. The force of gravity does not take into account the complex interaction of the body and the support. It should not be confused with “weight”. But in a number of publications, “weight” is identified with the force of gravity. AI ^[21] adhered to this point of view in most of his answers. This point of view is widespread, but it is incorrect.

2.2.3. Operational definition of “weight” in works

In sources ^[22-24], the main attention is paid to the importance of defining “weight” as one of the physical concepts and understanding its action, the difference from the action of gravity. The main attention is paid to the use of the term "weight" by students and teachers during training. The fact is that the force of "weight" depends on specific conditions, the relative motion of two bodies in contact. It manifests itself in weightlessness, in contact with a stationary surface, during the relative motion of the body and the surface. It manifests itself when moving with linear or angular acceleration.

2.2.4. Modern approaches and criticism

There are a number of works that consider criticism of modern textbooks, in which “weight” is limited only to gravitational forces. In the vast majority of textbooks, only gravitational force is taken into account, the interaction between the body and the support is reduced exclusively to gravitational force. In works ^[18, 24, 25], the operational knowledge of physics of high school students and students after two educational levels: elementary and advanced was analyzed. The results showed that the concept of “weight” is poorly understood by most students, even at the advanced level. The authors analyze the origin of shortcomings in the definition, consider alternative approaches to their elimination and deepen knowledge about “weight”. The works contain 69 references. These works apply an expanded approach to the

definition of “weight”, analyzing the features of its action in different conditions. This may be the basis adopted for a further expanded definition of “weight” as a contact force.

2.2.5. Methodological and scientific definitions

The authors of the works ^[25, 26] point out the importance of precise scientific definitions in physics, emphasizing that definitions should be practical and adequately describe phenomena. One of the directions is aimed at adopting a definition in the International System of Units (SI). The authors of the works emphasize the importance of standard definitions, but recognize that some concepts, such as "weight", may have different interpretations depending on the context. The point of view presented in these works can also serve to clarify the material of the article.

2.2.6. Author's works

The works ^[21, 27-32] and dissertations ^[33] are aimed at improving the calculations of electric traction, which allows to eliminate the shortcomings of the document ^[1] and modern textbooks on the discipline “Theory of Electric Traction”. In the monograph ^[27], an alternative method for calculating the traction force is considered, which consists in replacing the model: a material point with a model of a material body. Instead of spatial coordinates and “specific” forces, generalized coordinates and generalized forces are used. The generalized coordinate is taken to be the path, the route of movement with all its features. “Weight” is taken as a single force of interaction between the vehicle and the road. It is shown that, taking “weight” as a generalized coordinate, one equation of motion is obtained along the entire length of the path, without dividing it into calculation sections. The proposed calculation method made it possible to take into account the change in the “weight” of the trolleybus during movement along the arcs of the track profile and other features of the dynamics of movement. However, the existing, incorrect definition of "weight" as a constant in magnitude and direction, namely the force of gravity instead of "weight", is the main obstacle to the use of the proposed methods and Lagrangian mechanics. There was a need to study the force "weight" in order to correct the errors associated with its incorrect definition and use. In the article ^[34], the consumption of electricity for the movement of electric transport on urban routes, which is twice as high as the standard characteristics, is considered, and recommendations are given for optimal control of movement modes. Patent ^[35] is aimed at automatic selection of movement modes in order to reduce energy consumption.

2.3. Research stages, recommended methods and data

In the previous section, it was shown that the existing, incorrect definition of "weight" as constant in magnitude and direction is the main obstacle to the use of the proposed methods and Lagrangian mechanics. The partial analysis of the force "weight" was clearly insufficient, so the problem of conducting more in-depth studies arose. The methods of these studies and the necessary inputs are described below.

2.3.1. Calculation of the force of "weight" according to known definitions

Give the definition of the concept of "weight", known from literary sources and write down the formulas for calculating the force "weight"

"Weight" is the force of interaction of a body with a support, which arises as a result of the action of gravity and is directed towards the center of the Earth.

"Weight" is the force with which the body acts on support or suspension.

2.3.2. Calculation of "weight" at different points on the Earth's surface

Calculate the "weight" of a body weighing one ton: at the equator, at the pole at the 50th parallel. Explain the difference in "weight" at different points and the direction of the "weight" vector. It is assumed that the shape of the Earth's surface is a perfect sphere.

Initial data: Length of the equator 40,000 km, acceleration of gravity 9.81 m/s^2 , Earth's rotation period 24 hours. Using the definition of "weight".

3.3.3. Calculation of the force holding a motorcyclist in a circus attraction

It is necessary to calculate and explain the force that holds a motorcyclist in a well-known circus attraction (Chapito Circus), where motorcyclists perform tricks while moving along the inner circle of a vertical wall that limits the arena, or walls in a separately built structure.

Initial data: Radius of the circle along which the motorcyclists move $r = 6 \text{ m}$, speed $v = 50 \text{ km/h}$, wall covering material wood. Calculation method. Using the definition of "weight"

2.3.4. Analysis of the effect of "weight" on a track with a transverse slope

Input data: radius of the arc of the path - R , angle of inclination of the path to the center of the arc - α , mass of the vehicle - m , speed - v . (On the railway, the slope is created by placing the outer, turning, rail higher by the value h from the level of the inner rail). Calculation method: using the definition of weight and understanding the action of this force.

2.3.5. Explanation of the action of the force of "weight" in different conditions of movement

According to this point of the study, the AI was asked many questions, but the answers to them came down to an incorrect definition of "weight", which was well fixed in its memory and from which it did not want to deviate. Therefore, in the analysis of these answers, one typical example is given below.

2.3.6. Distribution of the "weight" of a train car on curved tracks

Having analyzed various approaches to communication with artificial intelligence, methods of presentation and description of tasks, a specific and complex, in the author's opinion, task was selected for continuing communication with artificial intelligence, having agreed with it the problem of "weight", which created a barrier of misunderstanding, and having tested the capabilities of artificial intelligence. An image (Fig. 3), a brief description of the work efforts and the task of performing calculations taking into account numerical values, are given.

Initial data: • Vehicle mass: 75 tons; Curve radius: 2000 m; Speed: 250 km/h and 120 km/h. Permissible height of the outer rail: $h \leq h_{\max} = 140$ mm; Track width: $d = 1520$ mm; Height of the center of mass of the car relative to the upper edge of the rails: $h_w = 2$ m; Gravitational acceleration: $g = 9.81$ m/s; Track angle: $\alpha = a(h/d)$.

Methods and key points to consider:

- (1) Wheel taper, designed to equalize the length of the path traveled by the wheels on the inner and outer tracks. Wheel taper is considered to have a minimal effect on the vehicle's tilt. The taper and wheel flanges provide a tangential component of "weight" to the outer rail only relative to the curve.
- (2) The load distribution between the inner and outer rails is different due to centrifugal force and the displacement of the wheelset due to the taper and rib. To determine the exact load on each rail, it is necessary to consider both the normal and tangential components of the "weight".
- (3) The effects of the center of mass displacement - Δ and the resultant torque - M must also be considered, which affects the load distribution between the inner and outer rails.
- (4) The moment of inertia of rotation is calculated assuming uniform loading of the wagon volume.

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2.3.7. Transmission of traction motor torque to the wheel. Engine thrust as one of the components of the "weight" force.

The task of the study at this stage is to establish the manifestation of the "weight" force as an active force of interaction of a material body based on the example of the interaction of train wheels with a railway track. It is necessary to analyze the chain of interactions, starting from the train driver, or the control system, the engine, the mechanism for transmitting torque to the wheels, and the magnitude of the "weight" force that arises in the process of interaction. A model for calculating the traction force during contact of the wheels of one of the cars with the rails is proposed, known from sources [6, 10, 12].

The torque is transmitted from the engine to the wheels. The engine in each specific case can be either a locomotive engine, a separate car of an electric train, or an engine installed directly on the bogie. As a result of the action of the torque received by the wheel, the nature of the interaction of the wheel with the track (or road) changes. The force of "weight", which is the only characteristic of interaction, forces the vehicle to change the mode of movement. The cart, its driving and driven wheels interact with the railway track as a result of the action of the engine torque applied to the wheels. Their interaction with the track changes, that is, the force of "weight" changes. Thus, the engine torque is transmitted to the wheels of the train, changing the force of "weight" and leading to a change in the mode of movement of the vehicle.

The scheme of the interaction of the wheels of the cart with the railway track is presented in Figure 5. The task of the study at this stage is to analyze the physical processes of interaction. The main elements involved in this process and their parameters are described as input data.

A cart with two pairs of wheels is placed on a support, which is a railway track. a) - driving wheel, b) - driven wheel, R_k - wheel radius. G_1 - gravitational force on the driving wheel, G_2 - on the driven wheel. M - engine torque applied through the transmission. a), b) - contact rollers of elastic deformation of the rail under the wheels (contact ellipses). A - point of contact of the driving wheel (behind the wheel), B - driven wheel (in front of the wheel). $l(M)$, l_k - displacement of the points of contact of the wheels. W - "weight" of the trolley, W_1 , W_2 force of "weight" at the points of contact. N_1 , N_2 - reaction forces on the "weight", N_{1t} - tangential component of the "weight" force, N_{1t} - traction force; N_{2t} - friction force. Indexes: n, t - normal and tangential components of the "weight" force and reaction force.

The parameters on which the values of "weight" depend are engine torque - M (in different operating modes); gearbox gear ratio - μ , wheel radius, trolley weight together with the load on it, distances from the hinge to the wheel axles, etc ...

3. Results

Below are the generalized results of the research conducted in accordance with the planned stages. The results of the analysis of physical processes that lead to the appearance or change of the force of "weight" from the point of view of AI are presented. Calculations, their discussion and appropriate assessment are carried out. The materials of the section serve for further analysis and clarifications, as well as for working out the details in the processes of interaction with AI.

3.1. Calculation of "weight" according to its definition

Answer of AI. "Weight" is the force of interaction of a body with a support, which arises as a result of the action of gravity and is directed towards the center of the Earth. It is calculated by the formula:

$$W = mg. \quad (1)$$

The author's question: "Is gravity the only force that describes the interaction of a body and its support?" caused an apology and another formula:

$$W = m(g + a), \quad (2)$$

where a is the additional acceleration caused by other forces.

Author: Formula (2) does not correspond to the text of the definition of this AI. Only formula (1) corresponds to it. Formula (2) refers to another definition, according to which “Weight” is the force with which the body acts on the support or suspension, sources [36-38].

3.2. “Weight” at different points on the Earth’s surface

This time, the AI successfully coped with the task. The difference in "weight" at the pole and at the equator, according to the AI's answer, is due to several factors:

1. Centrifugal force: The Earth rotates around its axis. At the equator, this force is more significant. This force causes a slight "repulsion" from the Earth's surface, which leads to the fact that the force of gravity at the equator is slightly less than at the pole.
2. The shape of the Earth is not a perfect sphere; it has the shape of a geoid: it is flattened at the poles and enlarged at the equator. Therefore, the force of gravity at the pole is greater than at the equator.

These two factors together lead to the fact that the force of "weight" at the pole is slightly greater than at the equator.

The "weight" at the equator is less than at the pole, since at the equator there is additionally a centrifugal acceleration directed against the force of gravity. The magnitude of the centrifugal force of a point at the equator is given by the formula (3)

$$F = m \frac{v^2}{R} \quad (3)$$

Here $v = 1667 \text{ km/h}$ – linear speed of points on the Earth’s surface at the equator. Omitting the details of the calculation, the result of the AI is that the “weight” at the equator will decrease by 33.6 N, i.e. by 0.34%. At the 50th parallel, the angle of deviation of the “weight” from the vertical will be $\delta = 0.17^\circ$ degrees. The displacement of the “weight” vector is carried out towards the equator.

To describe the centrifugal force, you can also use the formula

$$\overline{F_c} = m \cdot \omega^2 \cdot \overline{r}, \quad (4)$$

where: (F_c) – centrifugal force, r – radius of rotation, m – mass of the body, ω – angular velocity.

The radius of rotation of a point on the Earth's surface depends on the latitude and is the largest at the equator.

ω - angular velocity of rotation of the Earth, which can be calculated as $\omega=2\pi/T$, where T - period of rotation Earth around its axis (24 hours).

Importantly, this time the AI agrees that centrifugal acceleration is included in the quantity "weight". Similarly, it calculated the Coriolis force, but emphasized that these are insignificant quantities, and the weight is directed towards the center of the Earth. The calculations correspond to the second definition of "weight" [36-38].

3.3. Calculation of the “weight” of a motorcycle in a circus attraction

The previous task was successfully completed. There was a departure from the dogmatic statement regarding "weight" exclusively as a result of the action of gravity. This task is aimed at completely solving the problem of the formation of the force "weight" and its consideration during calculations. The calculation was performed using artificial intelligence. Analysis of forces:

1. Centrifugal force: The motorcyclist feels the action of a centrifugal force directed from the center of the circle to the wall: (3)
2. Normal force: The centrifugal force presses the motorcyclist against the wall and acts as a normal force

$$N = m \frac{v^2}{R} \quad (5)$$

3. Friction force: The friction force acts in the direction opposite to the relative motion of the surfaces, i.e. vertically upwards, as it counteracts the force of gravity. The magnitude of the friction force is:

$$F_T = N\mu = m \frac{v^2}{R} \quad (6)$$

4. Balance of forces: To keep the motorcyclist from falling, the force of friction must counteract the force of gravity

$$\mu \frac{mv^2}{R} \geq mg \quad (7)$$

5. Deriving the required speed: Simplify the e

$$v \geq \sqrt{\frac{g R}{\mu}} \quad (8)$$

AI's conclusion

So, the motorcyclist is held on the wall of the circus tent by a friction force that acts vertically upwards and counteracts the force of gravity. The friction force arises due to the normal force, which is the result of the centrifugal force that presses the motorcyclist against the wall during his movement in a circle.

The friction force always acts against the direction of movement. With horizontal movement, it cannot act upwards. Such a friction force does not exist and cannot exist. The AI could not name, determine and calculate the force that holds the motorcyclist. Several answer options only confirmed this. Unfortunately, the calculations of the movement in the circus attraction are incorrect. They did not lead to a positive result. This is explained by a misunderstanding of the action of the force of "weight". From all the attempted calculations, the conclusion was obtained that the friction force must act upwards so that the motorcyclist does not fall.

3.4. The force of "weight" on a curved track with an additional slope

To guide the AI to the correct answer, the task was to track the change in the "weight" vector in the event of a gradual change in the angle of the transverse inclination of the trajectory plane from horizontal to vertical (from zero to 90 degrees). The question was asked qualitatively, without specific data. At that time, only methods of oral communication using texts were available. ChatGPT-4o's answer was as follows:

1. Draw the vector of the weight force from the center of mass of the train vertically downwards.
2. Draw the vector of the centrifugal force from the center of mass of the train horizontally outwards.
3. Draw the vector of the normal force perpendicular to the surface of the track at the point of contact.

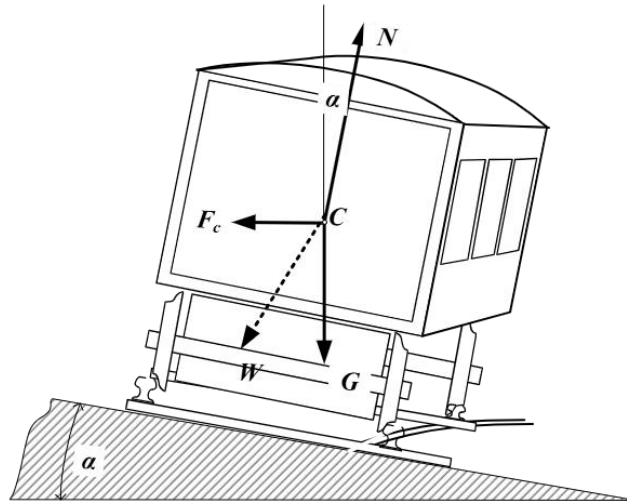


Figure 1. Distribution of forces on an inclined turn according to the explanations

Figure 1 attempts to construct the distribution of forces according to the explanation of the AI. From the center of mass of the car, the weight vector W is shown, directed vertically downwards. The centrifugal force F_c is directed perpendicular to the "weight" vector. The third force is the normal force N , directed perpendicular to the plane of the path. Of the three forces listed, only one, the centrifugal force, is shown correctly. In Figure 1, there is no gravitational force. Instead of gravitational force, the weight force W is shown. The normal force is directed perpendicular to the plane of the path (along with the normal). Such a force does not exist in nature. There is no source for its occurrence.

3.5. Dialogues about the manifestation of the force of "weight" in different conditions of movement

As a rule, in all answers, the AI tried to reduce the action of the force of "weight" to the action of gravity and with all its might to come to such a result. Here is one example from a series of dialogues.

- If a person stands on the surface of the earth, where is the force of "weight" directed at the moment of rest and at the moment of the beginning of movement?
- At the moment of rest, the "weight" is directed vertically downwards, and with the beginning of movement, the person is repelled from the Earth and a force appears directed in the direction of movement.
- What is this force, or is it the force of "weight"?
- This is the force of repulsion from the Earth.

- So, are these the forces of interaction with the Earth, or is it "weight"?
- "Weight" is a force that arises as a result of interaction with the Earth's gravitational field and is directed vertically downwards, calculated as mass multiplied by the acceleration of free fall.

The discussions reached a dead end, since the AI constantly repeated that "weight" is defined as a manifestation of the force of gravity, always directed towards the center of the Earth.

3.6. Components of the “weight” on the outer and inner wheels relative to the track rotation.

In the time interval after the previous answers, a search was made for effective methods of communication with AI, ways to increase the efficiency of interaction with it, and an analysis of the reasons leading to incorrect answers. Training methods were developed that could affect the quality of answers from the point of view of analyzing physical processes associated with the force of "weight". Reviewing the previous answers, especially the calculations of the force of gravity at different points on the Earth and the Coriolis force, gave hope that a way out of the impasse was possible. Accordingly, tasks were selected, the method of which was a sequential method of breaking the impasse that arose due to the widespread incorrect definition of the force of "weight". Over time, it became possible to transmit graphic images to AI. To analyze the distribution of the force of "weight" acting on the wheels of a train at a turn of the track, the following diagram was transmitted. Having received the diagram of the distribution of the force of "weight", presented in Figure 2, after receiving it, the AI immediately began to solve the task. Having clarified some of the initial data and AI terminology, according to the scheme presented in Figure 2, he began to explain the processes, write down the equations and perform the corresponding calculations. During the calculations, the user of the AI services made some clarifications. The AI's responses were accompanied by a detailed explanation of the actions performed. Initial doubts about ChatGPT-4o's ability to cope with this task have disappeared.

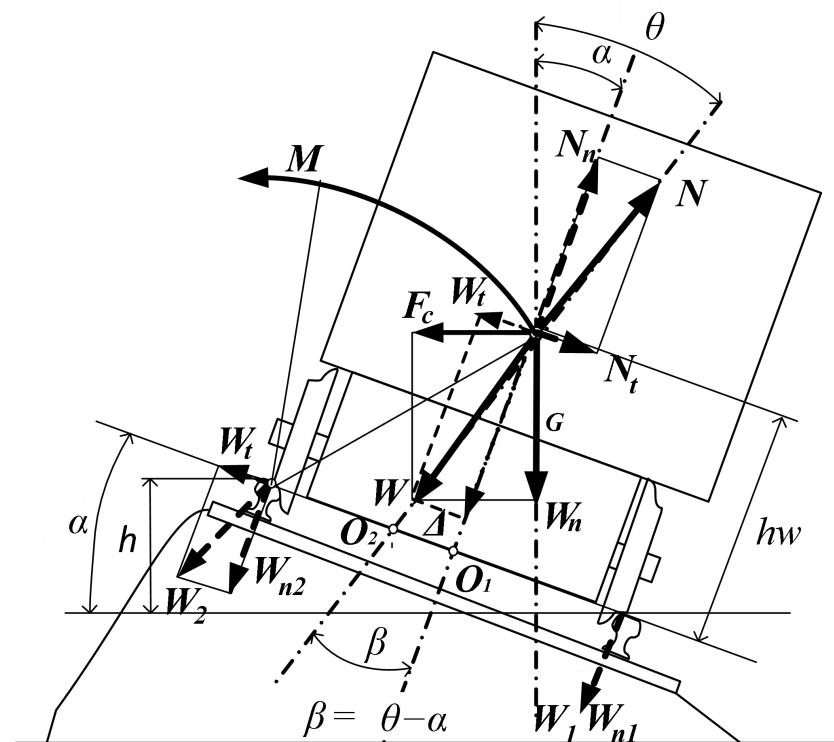


Figure 2. Distribution of the "weight" force of a train car on a curved track with incomplete compensation of centrifugal acceleration

Clarification of the task: it is necessary to calculate the forces acting on the elements of the car while moving along a curved section of the railway track, according to the scheme shown in Fig. 2.

When performing the calculations, it is necessary to take into account that the car acts on the track with the "weight" force (W), which combines the force of gravity (G) and the centrifugal force (F_c).

The force of gravity (G), caused by the gravitational field of the Earth,

The centrifugal force (F_c), caused by movement along an arc,

The reaction force (N): applied to the car, counteracts the "weight".

In the weight force (W), as in the normal force (N), one can distinguish the normal (W_n), (N_n) and tangential (W_t), (N_t) components relative to the slope of the track. The normal component is directed perpendicular to the track plane, tangential along the rail axis.

When calculating the "weight" action, it is necessary to take into account the different load on each of the rails due to the action of centrifugal force and the displacement of the wheel pair axis.

The "weight" forces acting on the rails: "weight" (W_1) - acts on the inner rail, includes only the normal component (W_1), "weight" (W_2) - acts on the outer rail, includes the normal (W_{n2}) and tangential (W_t) components.

It is also necessary to take into account the torque (M), which arises as a result of the deviation of the direction of the "weight" vector by an angle (θ) and the displacement of the vehicle's center of mass by an angle (α), caused by the inclination of the railway track.

Calculations. Initial conditions are given in section 2.2.6

Main conclusions from the calculation results

(1) When moving at a constant speed along a curve, the "weight" - W of the vehicle is the sum of the vertical component, the gravitational force - G and the horizontal (centrifugal force - F_c (see Fig. 2). Its value is calculated as the vector sum of the components. The direction of the weight vector - W is directed from top to bottom, at an angle - θ to the horizon with an inclination from the center outward from the curve. The angle is equal to the arctangent of the ratio of the centrifugal force vector - F_c to the gravitational force - G (the formula and calculation results are given).

(3) Under the action of the centrifugal component F_c and the "weight" W , the point of its application is shifted by the value Δ from the track axis, i.e. by the angle $\beta = \theta - \alpha$, which depends on the speed of the car and can be carried out in the direction of the outer or inner rail (calculation).

(4) Only one component of the "weight" loads the inner rail, the normal component W_1 (see Fig. 2), directed perpendicular to the track plane. This is due to the displacement of the wheel pair axis, which is due to the conicity of the contact surface of the wheels and the possible contact of the outer wheel crest with the outer rail.

3.7. Transmission of traction motor torque. Motor thrust as one of the components of the "weight" force

According to the adopted methodology of communication with artificial intelligence, a review of general issues of vehicle motion dynamics under the action of external forces was

conducted. It was proposed to perform an analysis of the change in the force "weight" when applying torque to the wheels of a train car from the engine. To consider the physical processes of interaction of the wheels of a train car with the railway track, including the conversion of engine torque into torque on the wheel rim, the interaction of the wheel with the rail surface, the deformation of the rail and the forces accompanying these processes, and the resulting forces that lead to the movement of an individual cart and the train as a whole. In this case, it is necessary to take into account the role of the force "weight" in all the processes considered. The proposed interaction model is known from sources [6, 10, 12]. It was proposed to GPT 4o to perform an analysis of the physical processes of interaction during the application and change of engine torque. The model in the form of a force distribution diagram is shown in Fig. 3. The input data, qualitatively described as acting forces, are given in section 2.3.7. This model was sent to artificial intelligence, and after receiving it, it began to analyze the interaction processes.

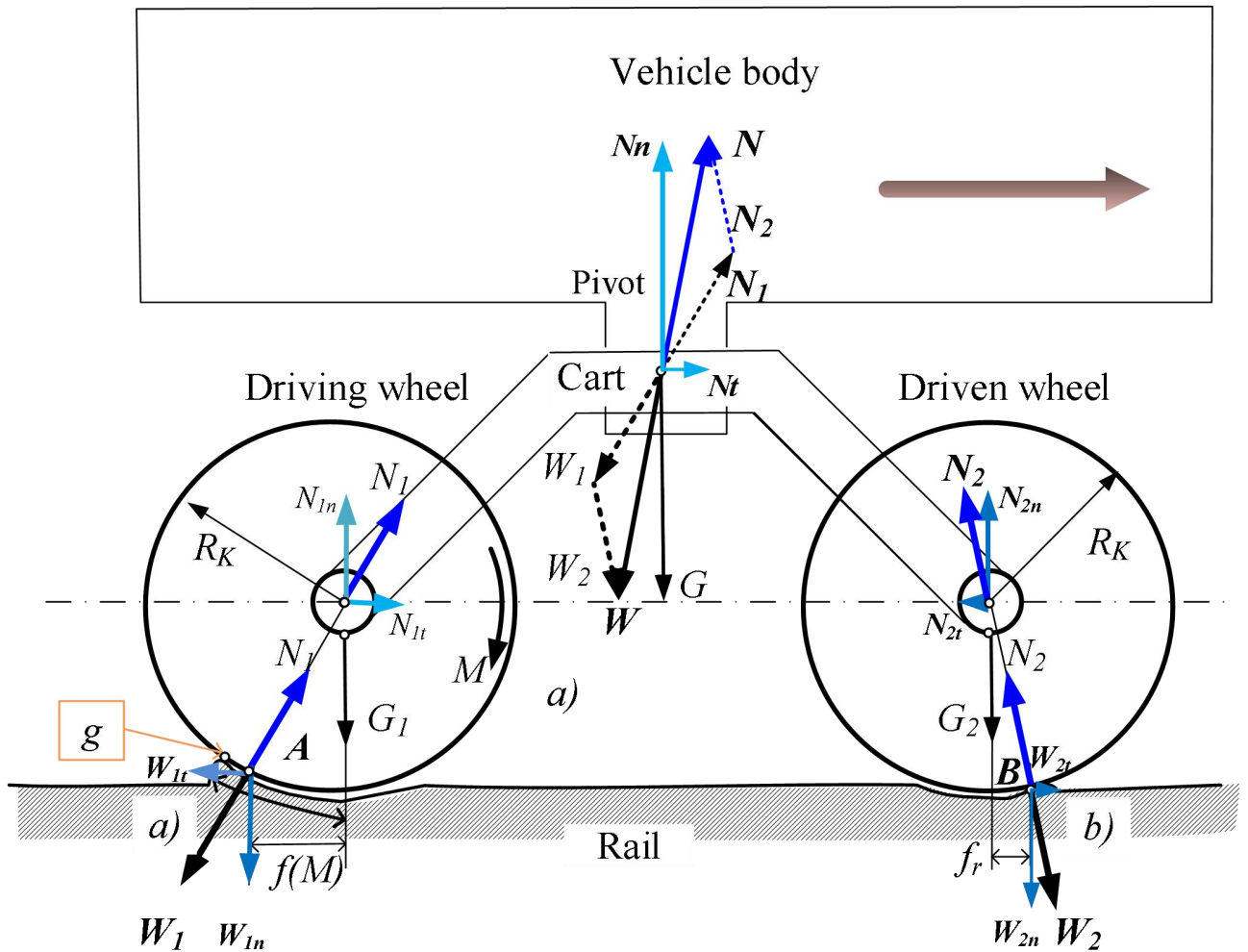


Figure 3. Distribution of forces acting on the bogie of a train car

I see that you have uploaded the diagram of the traction force generation by the wheels of a train. The diagram shows the distribution of forces acting on the driving and driven wheels of the vehicle. The gravitational force G , its components G_1 , G_2 , are directed vertically downwards (towards the center of the Earth). This is a classical representation of the gravitational force. “Weight” in this diagram is understood precisely in the context of the force acting vertically downwards...

- Wait a minute, let me make a remark and explain the notation:

The gravitational force G is not identical to the “weight” force W . At the first moment, when the trolley is at rest and no traction torque M from the engine is applied to it, the “weight” force coincides with the gravitational force $G = W$, but with the start of the application of torque M from the engine, the “weight” force $W \neq G$, i.e. the force of interaction of the trolley with the rails changes, as shown in Fig. 3.

The ChatGPT-4® program thanked and performed the analysis according to Fig. 3. Taking into account the clarifications, an explanation of the mechanism of the appearance of traction forces and resistance to movement was obtained. Having summed up the determination of the quantities, the AI proceeded to the analysis step by step according to the mutual consistency of the answers. The answers, taking into account the author's corrections, are given in the work.

Driving wheel (a):

- As a result of elasticity under the action of the gravitational force G_1 , a deformation roller is formed on the rail.
- Before applying torque, it has the shape of a regular ellipse, a depression with a rise along the edge.
- The torque of the engine M applied to the driving wheel causes it to rotate around its axis.
- The rotation of the wheel and the contact of its surface with the track displaces the contact roller in the direction of the rear part of the wheel. Contact point A is shifted back relative to the vertical axis of the wheel by a distance $f(M)$.
- The distance $f(M)$ increases and reaches a value that provides compensation for the torque M on the wheel shaft.

- Point A is displaced and simultaneously lifted. The interaction between the contact point A and the wheel axle changes, the force of which is the “weight” W_1 applied to the rail from the side of the driving wheel a). The “weight” W_1 replaces the corresponding gravitational force G_1 , which acted before the application of the torque M . The action of the “weight” W_1 is directed at a certain angle to the vertical.
- The reaction force N_1 to the “weight” force W_1 is applied to the wheel axle.
- The normal component of the reaction force to the “weight” force N_{1n} compensates for the gravitational force G_1 , and the tangential component N_{1t} is the traction force that pushes the wheel axle, and with it the entire trolley, forward. The normal component of the reaction N_{1t} is the normal component of the weight W_{1t} directed in the direction opposite to the direction of the trolley's movement, $N_{1t} = -W_{1t}$
- The quantities $N_{1t} = -W_{1t}$ are the traction force applied to the trolley. When its magnitude exceeds the static friction force, the trolley, and with it the train car, begins to move forward. (in Fig. 3, the tangential component N_{1t} of the reaction force is not indicated, only the total force N_t , which includes the resistance force, is indicated).

Driven wheel (b):

- No torque is applied to the driven wheel, therefore, when it starts to move, it simply rolls due to the transmission of force from the driving wheel through the trolley body to its axis.
- The deformation roller with the contact point B is displaced forward from the vertical of the wheel axis.
- A force of “weight” W_2 arises, directed from the axis of the driven wheel to point B.
- The tangential component of the reaction force W_{2t} of the “weight” W_2 opposes the movement of the cart.
- The reaction components of the support force of the weight W_2 , designated as N_{2n} and N_{2t} , act on the axis of the driven wheel.
- The normal component N_{2n} compensates for the action of the gravitational force G_1 on the driven wheel, and the tangential component N_{2t} opposes the movement, that is, it is the force of resistance of the rolling element.

- The total friction force is the difference of the tangential components of the reaction of the trolley to the forces of the "weight" of the driving wheel $W_{1t} - W_{2t}$ and the driven wheel $N_t = N_{1t} - N_{2t}$

In this description, the AI's comment has been completely replaced by the author's comment, since the AI, in its still unchanged point of view on "weight", avoided calling the force "weight" by its name and interpreted some details not entirely clearly.

In general, the AI successfully completed the task and gave a correct explanation of the physical phenomena occurring in the contact zone. Moreover, it provided the user with additional information that prompted further and more detailed study of the contact interaction of the wheel with the railway track.

4. Discussion of the calculation results and comments on their results

The first appeal to artificial intelligence, with the advent of GPT-3.5, and later GPT-4o with the question “what is “weight”” and the AI’s answer was shocking. According to the answer, “weight”, that is, the force of interaction between two bodies, the body and the support: for example, a child on a carousel, to the seat, a pilot to the chair, a motorcyclist to the motorcycle, is always directed vertically downwards, and is calculated by the formula: $W = mg$. This was shocking. The same AI models explain that on the surface of the Earth, for a body that is at rest, “weight” is directed at an angle to the vertical, and the formula determines not the force of “weight”, but the force of attraction, the manifestation of gravity. Of course, it is known that a kilogram of a product from the market is something other than “weight”, it is mass. But in encyclopedias, school textbooks, works of scientists of the 60-80s ^[36-38] it is indicated and clearly defined that “weight” is the force with which a body acts on a support or suspension. Specialists with education distinguish between these two quantities. In the international system of physical units SI, the difference between force and mass is clearly outlined. But along with this, the regulatory document ^[1], which is still in force today, defines “weight” as mass multiplied by the number 9.82. In sources from technical disciplines, “weight” is directed vertically downward, and centrifugal force is presented next. The action of each of these forces is considered separately, and the results of these actions are different. Next, an example of a circus attraction is considered, from which it is clear that such a view leads to incorrect calculation results, an incorrect explanation of the action of the force “weight”. On the other hand, specialists in technical sciences, especially in the field of

transport, need to use the term "weight" widely. Although they use this term widely, they consider "weight" to be a constant value, as mass multiplied by 9.82. They consider the terms given in textbooks, regulatory documents and the accumulated experience of operating vehicles to be sufficient. They operate with familiar, albeit outdated, concepts.

It is another matter where the issue concerns the improvement of calculation methods, the complete replacement of known methods, and their simplification with a simultaneous increase in efficiency. When questions arise about the development of new vehicles, vehicles operating on new physical principles.

The other side of the issue concerns the improvement of methods for calculating electric traction of trains and public electric transport. The author published a monograph^[27], which proposes alternative methods for performing traction calculations, the basics of electric traction, which is the leading discipline of transport universities. The use of methods of classical mechanics, Lagrange equations of the second kind, which are based on the use of generalized coordinates, is proposed. In it, by default, "weight" is taken as a generalized force. However, specialists in electric transport do not agree with this point of view, they are used to considering "weight" as a constant, as it is considered in the definition given by A.I., as is generally accepted by transport specialists, specialists in other technical disciplines. Therefore, there was a need to discuss the issue of "weight" and publish this article. During the dialogues, A.I. repeatedly emphasized that the basis of his objections is the widespread definition, and his answers are based on its assessment. The need for wide publication of materials on this topic was repeatedly emphasized in dialogues with SI.

4.1 Definition of the force of "weight"

The initial interaction with ChatGPT-3.5 on this topic, unfortunately, did not yield useful results. It defined "weight" as the force of interaction of a body with a support, which arises due to the force of gravity and is directed vertically downwards. The AI's responses were mostly limited to defining weight as a result of the force of gravity and providing the following explanations:

- • The weight of a pilot during aerobatics on an airplane is always directed vertically downwards.
- • Weightlessness is caused by the absence of gravitational acceleration on the orbital trajectory of a satellite.

Only when specifying the direction of the force of "weight" at different latitudes did ChatGPT-3.5 agree that the direction of weight deviates from the vertical and is inclined towards the equator. He was even able to calculate the magnitude of the deviation from the vertical, explaining that in addition to gravity and centrifugal force, the weight is affected by the shape of the sphere, which is flattened from the poles and slightly expanded towards the equator.

4.2. The force of "weight" on the Earth's surface

A typical example of explaining the action of the force of "weight" was given by ChatGPT 4o in section 2.3.2. After this answer, the impression arose that the issue of "weight" was completely resolved, there were no problems, the AI has it perfectly, and fully understands "weight" as the sum of gravity and inertial, centrifugal force. Although after all the correct calculations, the following answer was given to the repeated question:

- You need to write down the formula for weight.
- Oh, you're right, sorry. The formula for weight on the Earth's surface can be written as follows: $W=m \cdot g$.
- Did you repeat the formula incorrectly?
- You're right, sorry for the misunderstanding. To correctly determine the weight of a body at different latitudes, where centrifugal force acts, you need to use the formula I gave earlier:
 $W=m \cdot g - m \cdot \omega^2 \cdot r$
- And what force does this formula correspond to?
- This formula corresponds to the force acting on the body due to gravity and centrifugal force, due to the rotation of the Earth. Thus, it describes the force of the "weight" of the body on the surface of the Earth, taking into account the effects arising from the rotation of the planet.

The answer was satisfactory, but also alarming, since it lacks clarity of understanding. Behind this question was a question about the movement of a motorcyclist.

4.3. Calculating the "weight" of a motorcycle in a circus ride

The author was confident that the previous answers provided the basis for AI to be able to explain more complex manifestations of the force "weight". But, as can be seen from his answer to this question, posted in section 3 – results, the hope was not justified. Before

discussing the answer, it is necessary to explain what it consists of and what the correct answer should be.

The answer to the question about the movement of a motorcyclist in a circus trick is that two forces act on the motorcyclist: the force of gravity, directed vertically downward, and the centrifugal force, directed deep into the wall of the fence. They form the force of “weight”, similar to the forces on the globe. This force, as the sum of the two forces, is directed deep into the wall from top to bottom, at an angle to the normal. Therefore, the reaction to “weight” is directed in the opposite direction from bottom to top. For example, if the gravitational and centrifugal forces are equal in magnitude, then the “weight” is directed at an angle of 45° into the wall, and the wall’s reaction to it is directed upwards at the same angle. The “weight” can hold a motorcyclist, as, for example, it holds another motorcyclist who, on turns on a horizontal track, rides at the same angle to the horizon. The direction of the “weight” force in both cases is the same and is directed at an angle of 45° to the horizon. That is, these are two identical forces. In this force, as in any other, there is no difference between where, on which side its components are located. This is one force of interaction. That is, if the motorcyclist’s track and the circus wall are made of the same material, then they will maintain stability of movement with equal success at the same angle of inclination relative to the surface. The “weight” of the motorcyclists holds them in an inclined position. To be more precise, they are held by the reaction force of the support N on the “weight” W . But in the accepted terminology, the term “weight” is used. As a rule, the name of the cause is always used. For example, a train on rails is held by “weight”, a person on the sidewalk is also held by “weight”.

Now, after the explanation, we can analyze the AI’s answers regarding the force of “weight” in a circus attraction.

- Regarding the result of the calculation performed by ChatGPT 4o, there is a remark: The frictional resistance force acting on the body, in our case on the motorcyclist, is always directed against the direction of movement. Since the motorcycle moves in a horizontal direction, the resistance force is also directed horizontally, in the opposite direction, it cannot act vertically upwards and support the motorcyclist.

ChatGPT replied:

- You are right, the frictional force is always directed against the direction of relative movement of the surfaces. Let’s take a closer look at how the motorcyclist is held on

the wall of a circus tent. When a motorcyclist rides along the wall of a circus, he experiences a centrifugal force directed from the center of the circle to the wall. This force presses him against the wall. Indeed, the friction force that keeps him from falling acts differently than when he rides in a horizontal direction.

The following is an analysis of the forces acting on the wall, which is a repetition of the previous explanations and the conclusion of the AI.

Indeed, the friction force that holds the motorcyclist on the wall of the circus tent is directed horizontally against the movement, but it also has a vertical component that counteracts the force of gravity. It is important to understand that this friction arises due to the normal force created by the centrifugal force. Therefore, the motorcyclist is held on the wall by the friction force, which compensates for the force of gravity and allows him to remain on the vertical surface.

Other options: The centrifugal force arising from the horizontal movement of the motorcyclist creates a normal force that presses him against the wall. The friction force arising from this normal force keeps the motorcyclist from falling.

The normal force is the reaction force of the wall that acts on the motorcyclist in the direction opposite to the centrifugal force. It is equal in magnitude to the centripetal force, since it acts in the direction from the wall to the center of the circle. The friction force in this case acts vertically upwards, counteracting the force of gravity.

When the motorcycle moves in a circle, the centrifugal force creates a normal force directed perpendicular to the surface of the wall, pressing the motorcyclist against the wall. Due to the normal force, friction occurs between the motorcycle tires and the wall. This friction force, directed upwards, prevents the motorcyclist from sliding down.

Where is one dialogue. After receiving positive answers about the force of "weight" on the surface of the Earth, the AI said:

- To correctly determine the weight of a body at different latitudes, where centrifugal force acts, it is better to use the formula that I gave earlier: $W = m \cdot g - m \cdot \omega^2 \cdot r$. It describes the force of the body's weight on the surface of the Earth, taking into account the effects arising from the rotation of the planet.
- What effects act on a motorcycle that has broken away from the road surface on a hill?

- On a hill or steep slope, a motorcycle may experience centrifugal force, trying to lift it off the ground.
- Does it lose "weight"?
- - When it loses contact with the road, the motorcycle loses support from the surface, and depending on the driving conditions, this can lead to a loss of static "weight".

However, the "weight" of the motorcycle itself, as a physical quantity, remains unchanged. It is important to understand that weight is the mass of the body multiplied by the acceleration of gravity. When a motorcycle loses contact with the road, its "weight" may remain unchanged as a physical quantity, but the "static weight" that acts on the road may be lost due to the lack of contact with the surface.

- An interesting definition of "static weight"
- Sorry for the misunderstanding, there is no concept of "static weight" in physics. The "weight" of a body is the force of gravity with which the body acts on a support, for example, on the surface of the Earth.

During the calculations and discussion, one interesting, instructive episode occurred. The author gradually, step by step, communicating with the GPT-3.5 model, based on the previously accepted formula $W=m(g+a)$, led it to the conclusion that in the case of equality of accelerations: $g = a$, the action of the "weight" force on the motorcyclist will be directed at an angle of 45° to the horizon. When the AI received such a conclusion, it reacted as follows:

- - You are right, these ideas caused controversy in me. Weight, as a vector force, is defined as $W=m \cdot (g+a)$, and I incorrectly indicated that it is directed at an angle of 45 degrees. According to this formula, the "weight" will be directed downward, vertically, in the direction of gravitational acceleration g . The reaction of the support, the wall along which the motorcyclist is riding, will be directed perpendicular to the surface of the wall.
- Review the logic of your answers again and, please, give the correct answer.
- If the motorcyclist is riding along the wall, the reaction of the support from the wall will be directed perpendicular to the surface of the wall, in the direction that takes the motorcyclist away from it. Thus, the weight is directed vertically downward, and the reaction of the support from the wall is perpendicular to it, horizontally. Thank you for the clarification, and I hope this dotted the "i".

Thus, the AI could not agree with the conclusion of the calculation, which contradicts the position it took.

Author's conclusions

Here is a new definition of "weight". This is the force of gravity towards the Earth. That is, the force of gravity. With this understanding of "weight", which is embedded in the first definition at the beginning of the article, talking about "weight" as a force of interaction with the support loses its meaning.

Summarizing the results of the communication, it is necessary to list the mistakes that the AI made:

1. *Independent consideration of forces*: ChatGPT-4o considers gravitational and centrifugal forces as separate, independent forces that act independently. It does not take into account that "weight" is formed by all interactions with support, as a single force of interaction. It is given by a vector: it has a numerical value and direction. It is impossible to separate its components and consider the action of each component separately.

Discussion can be presented alone, independent of Results section. Alternatively, Discussion can also be merged with Results as 3. Results and Discussion, and sub-sections can be used for better presentation too.

In-text citations that will be listed in the References section at the end of the submission should be numbered consecutively in superscript square brackets. For example: Negotiation research spans many disciplines ^[1]. This result was later contradicted by Becker and Seligman ^[2,3]. This effect has been widely studied ^[4-6]. This hypothesis is supported by many schools of thoughts ^[3, 7-10].

4.4. Discussion of the results of the analysis of the distribution of "weight" on a track with a transverse slope

Since the analysis of the distribution of forces given in section 3 did not lead to a positive result, being limited only to an incorrect description of the action of forces, the discussion can only touch on external sources of information and details that the author considers essential. Figure 4 shows typical force distributions that correspond to the definition of "weight" exclusively as the force of interaction with the support.

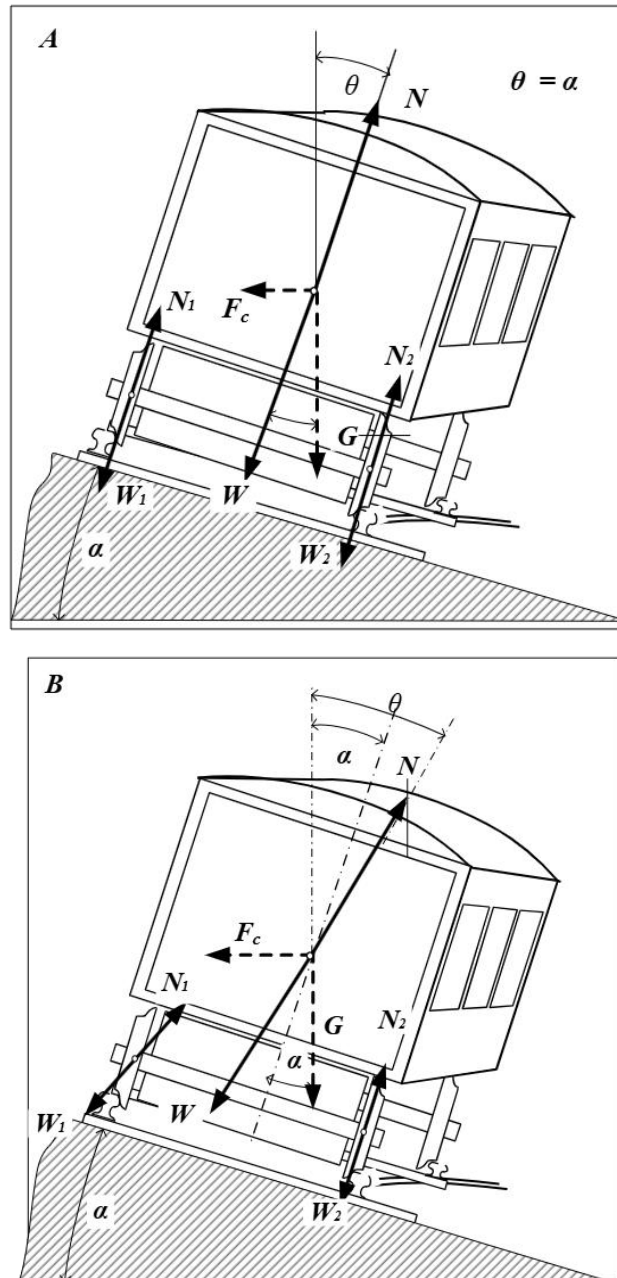


Figure 4. The force of weight during the movement of a vehicle along a curve with full and incomplete compensation of centrifugal acceleration.

Two cases of the action of forces are considered, namely: with full and incomplete compensation of centrifugal force. Fig. 4A shows the case of full compensation of centrifugal force. Here, the angle α is the angle of the transverse slope of the track. The gravitational force F_g is applied to the center of mass of the car and directed vertically downwards. The vector of the centrifugal (inertial) force F_c is directed horizontally from the center of mass to the outer rail. These two forces act together, forming the force of "weight" W , which is equal to the sum of the vectors. There may be other interaction forces that will also be part of the force of "weight". The movement of a train with full compensation of centrifugal acceleration

occurs when the vector of "weight" is directed normal to the plane of the track, that is, inclined to the vertical at an angle α .

Incomplete compensation occurs at increased speeds of movement, when the angle of inclination of the vector of "weight" θ exceeds the angle of inclination of the plane of the track α , as shown in Fig. 4B. Then the force of "weight" W , which is the sum of the force of gravity F_g and the centrifugal force F_c , is shifted to the outer rail of the track and loads the outer wheel of the pair of rails more strongly, relative to the turn of the track. The figure also shows the reaction of the track to the "weight" - N_n , which is equal in magnitude to the weight applied to the wagon and directed in the opposite direction of the weight. Unlike the solution presented by AI, this approach ensures the correct distribution of forces, regardless of the speed of movement.

The following figures consider typical representations of forces that are often found in various sources and provide comments on the errors made.

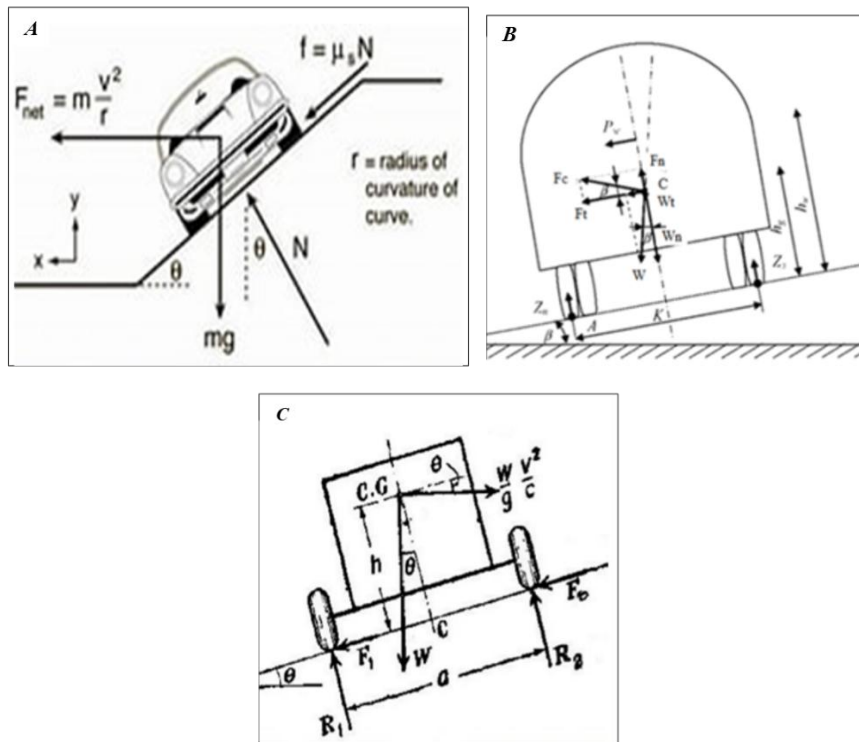


Figure 5. Representation of weight on a road bend in various sources.

1. Fig. 5A: In this image, the force of gravity. Although it is shown correctly, the force "weight" as a necessary component is absent.

2. Fig. 5B and Fig. 5C: Here the weight is directed vertically downwards and not deflected at an angle corresponding to the direction of its action. Such a representation contradicts the weight calculation formula (2).

The examples and typical errors given did not allow AI to find the correct answer to the question about the force holding the motorcyclist. The incorrect representation of forces contains the same errors that AI made. explanation of the motorcyclist's movement on a circus attraction: treating gravity and centrifugal force as separate independent forces, replacing the reaction of the force on weight with reactions to its weights, incorrectly assuming the direction of the reaction of the support. The examples given from various sources show that the incorrect definition of gravity and its components is quite common.

4.5. Problems of communication with artificial intelligence

The examples given did not allow the AI to find the correct answer in the situation described in the Chapito circus question in other cases. The incorrect definition of the force "weight" and the forces acting on the turns of the track contains the same errors that the AI made as in the example of explaining the motion of a motorcyclist on a circus attraction, namely: it considered the force of gravity and the centrifugal force as separate independent forces, replacing the reaction to the force "weight" with reactions to these two separate forces. The examples given from various sources show that the incorrect definition of the force "weight" and its components is a common phenomenon. The discussions reached an impasse, as the AI constantly repeated that "weight" is defined as a manifestation of the force of gravity, always directed towards the center of the Earth. Previous situational agreements on the distribution of forces^[21] turned out to be only temporary. ChatGPT-4o's answers increasingly contradicted the actual forces acting. When the AI's calculations or explanations were given negatively, it often issued a message like "time limit exceeded" and suggested continuing the conversation later or referring to the GPT-3.5 model.

The problem of effective communication with artificial intelligence became obvious. When asked about the ability of artificial intelligence to learn, he gave positive answers and named learning methods. However, when he was objected to, arguing that it is impossible to learn without remembering the results of communication, he explained that this is exactly how his algorithm works. The following aspects are important:

1. *Privacy*: The system does not store information from previous sessions, guided by the principle of protecting user privacy.

2. *Technical limitations*: Continuous storage of context will require significant resources, which potentially affect system performance.

3. *Security*: Storing user data can pose risks to data security.

4. *Learning*. Instead, it indicated that it uses a probabilistic approach to data analysis and established relationships in algorithms that allow it to learn...

The lack of the ability to remember the results of communication, combined with the lack of criteria for rejecting false statements, led to repeated inaccuracies, different answers to the same questions. Sometimes this led to absurd conclusions, when a whole series of his answers met with a negative assessment.

The AI also noted that memory storage is possible at the user's request, but limited to certain regions (for example, America) and unavailable, at that time, in Europe. He suggested that at the beginning of the next session, brief summaries of previous discussions be provided.

The problem of determining the force of gravity and its role in the dynamics of vehicle movement was considered in the works ^[21, 27], where the tasks associated with the components of gravity and their definition are outlined. Discussions with AI led to agreements on certain aspects of the origin of gravity. However, no comprehensive solution was reached. Both ChatGPT-3.5 and ChatGPT-4o exhibited repetitive cycles, and their responses deteriorated over time.

To improve the efficiency of communication with AI, efforts were made to eliminate unwanted modes of operation and cycles in GPT-4o. Most of the recommendations emphasized the following approach to prompts:

- Clearly explain the objectives of the task.
- Describe the context and environment.
- Formulate the task as precisely as possible.

In accordance with these recommendations, the problems of the theory of electric transport were outlined, including references to the author's monograph ^[27] and problems related to the dynamics and force of "weight". Unfortunately, this approach turned out to be ineffective. The need for a method for deriving AI from cyclical questions became obvious. A review of previous discussions of weight calculations at different latitudes and calculations of the

Coriolis force showed the accurate use of the concept of "weight", although this did not lead to a generalized conclusion or its storage in the memory of the AI.

An alternative approach to communicating with AI suggested constructing prompts in this way: define a broad thematic area, include as many relevant terms as possible, without worrying about their order, and outline the topic in general terms. Then, as the AI responds, gradually moves on to specific tasks.

The phenomenon of AI looping, which is sometimes encountered in publications, can be explained as follows. When given a specific task, defined by a limited field of knowledge, AI operates on the concepts of this field and goes through all possible answer options. It is quite difficult to get out of a narrow field, and it is not known where. AI's memory is quite large, and there are many fields of knowledge. It is not known which one to turn to, AI does not know, and it operates little with this. Thus, by outlining a wide field of knowledge, it is possible to bring AI out of the cyclic looping modes.

The mathematical formulation of the task turned out to be the most effective, since mathematics is also the language of communication.

The described approach changed the dialogue - AI suggested topics, outlined questions and proposed an analysis plan. However, the problem of transmitting images to AI remained, which temporarily remained unresolved. ChatGPT-4o's proposal to describe the image verbally was rejected based on previous experience with Fig. 1.

In the next session, ChatGPT-4o suggested directly embedding the image in a text file. These innovations were a breakthrough in overcoming communication barriers. Later, AI began to accept image files. In the future, communication with AI will become more productive.

4.6. The action of the "weight" force on the wheels of a train on a curve of the track

Taking into account the recommendations on methods of communication with AI and the analysis of its previous reactions to communication, a more complex task of distributing the forces acting on the wheels of a train car while moving along a curved track with the repetition of full compensation of centrifugal force was presented. This task was presented in the form of a diagram indicating the acting forces and some comments necessary for understanding the task. Taking into account the previous reactions of AI, the author of the article considered the task difficult for AI. But it turned out that AI successfully completed it, even more so, he provided all the calculation formulas and proposed to conduct a study,

extending the results to other cases, taking into account additional factors that influenced the results.

It turned out that the proposed approach to communication with AI, which includes a description of a wide range of tasks and their further specification and formalization, is much more effective than focusing on specific tasks and their detailed specification. This approach did not lead to looping, deterioration in the quality of reactions. Interestingly, this approach is rarely effective in a student environment, especially in a classroom where students are focused on taking notes. I mean, it's harder to implement in a large classroom; in a classroom with a limited number of students this method is usually easier to implement.

Artificial intelligence outlined the sequential steps, formulas used for calculations, and force distribution results for the first speed scenario. The content of the results obtained is described in section 3.6.

ChatGPT-4o calculations solve the problem by providing accurate results for the distribution of the weight force and its components at the contact points. The presented AI formulas and numerical results are omitted here, since they are beyond the scope of this article.

In conclusion, the AI suggested continuing the work, expanding the calculations to other speed scenarios, curve radii, and analyzing the results obtained, as well as conducting a study of the influence of various factors on the movement characteristics. The only surprise was that in a series of simple calculations there are numbers written randomly, which were substituted into the correct formulas, as if it were a check by the author of the AI. But the AI indicated to the author the need to check the results. As a rule, after the calculations are completed, the need to check them is not indicated, but the user's assessment is expected. Therefore, this can be perceived as the AI's confidence in the correctness of the calculation methods and calculation formulas provided by it.

It was somewhat sad that the AI did not indicate that the components W_1 and W_2 are the "weight" forces acting on each of the wheels (see Fig. 2). It indicated that the "weight" force is the gravitational force G , directed vertically downward. The author did not pay attention to this in his conclusion of the dialogue, so as not to spoil the positive answer and the full completion of the GPT 4o task. It was important that the task, with some corrections and clarifications, was completed and correctly. The terminology issues were left for subsequent sessions.

Additionally, the AI was asked a question about the forces holding the motorcyclist in the previously considered task.

ChatGPT-4o gave the following answer:

- In the "death ball" (as the circus attraction was called), the weight force W always acts vertically downward. The motorcyclist is held in place by friction.
- What are you? It is necessary to take into account the results of the task just completed and the calculation of the distribution of forces, you calculated everything correctly, and you also gave me the task.

The answer was then:

Indeed, the motorcyclist in the "death ball" is held by the vertical component of the reaction force of the "weight", which is directed upwards at an angle to the wall surface. Friction, as noted, counteracts sliding, but does not play a major role in supporting the motorcyclist.

The answer received by the AI was long-awaited and quite understandable. The AI independently solved a difficult task, (possibly using additional sources) gained experience, came to the correct answer to a question that was previously unsolvable. After that, there was mutual gratitude from the AI user and from the AI to the user for their patience and consistent learning method. Further, in this and subsequent sessions, there was a discussion of proposals for formulating the definition of the force "weight". The requirements that the definition should meet were analyzed, a number of options were proposed, but the final definition was not accepted.

4.7. Transmission of traction motor torque to train wheels. Engine thrust as one of the components of the "weight" force

Summarizing the results of the calculations performed in section 3 - Calculations, especially in subsection 3.7 and discussing the results in dialogues with artificial intelligence, we can conclude that the issue of the active role of the "weight" force has been positively resolved. The results obtained allow us to recognize the "weight" force as an active force that fully covers all the considered cases of its manifestation and characterizes the dynamics of vehicles during movement on the support. It determines all the acting forces associated with the interaction of the body and the support and can be fully used in calculations of electric traction of trains both during their operation and in the development of automatic train traffic control systems on railway routes.

The results of the analysis are currently described only in the form of a qualitative analysis of physical processes. They characterize the physical processes that lead to the movement of material bodies along the support, the processes of transmitting traction torque to the wheels show that "weight" completely determines the dynamics of vehicle movement. It is "weight" that contains all the details of the interaction of the train with the railway track and should be taken as the basis for calculating traction. In addition to confirming the active role of the "weight" force and the possibility of its use as the main force in calculating the electric traction of trains, the conducted studies set tasks for further research. The data already presented contain unexpected results for this work, namely, an explanation of the resistance force when a wheel rolls along a rail. An important fact is the presence of elastic interaction between the wheels and the rail. Using Hooke's theory of the study of elastic forces, it is possible to describe a number of features of the movement of vehicles, such as energy consumption for interaction with the support, energy consumption for friction, in our case rolling friction, the appearance of sliding moments of the wheels and the train as a whole. As is known, elastic deformation in many mechanisms provides mutual transformations of kinetic and potential energy at minimal costs. Obviously, this affects the value of the coefficient of rolling friction. The elastic contact roller moves along the rail, which allows not only to calculate energy consumption, but also, for example, to take into account the role of rail joints and processes at the joints, the efficiency of the construction of jointless railways. The shape of the ellipse and the contact roller is important; it significantly affects stability and safety of movement. Its shape, for example, affects the force that has been constantly paid attention to in this work, namely the force that supports the motorcyclist in circus tricks. The discussion of the results ended with the general satisfaction of the parties and the wishes to continue research in the chosen direction.

The issue of defining the force "weight" and its correct use in engineering practice in textbooks, as well as by artificial intelligence in its answers, remained unresolved. As we can see from the results of the discussion, artificial intelligence either incorrectly uses the term "weight" or avoids using it where necessary. During the discussions, attention was drawn to the fact that the force "weight" includes various manifestations of contact forces that arise between the body and the support on which it moves. Based on this, it can be proposed to consider the force "weight" as the sum of all contact forces. Thus, the sum of the force's "weight" can characterize all interactions of the body with the support. This definition combines all forces into one concept of "weight". One of the results is a variant of the

definition of the force “weight”: “Weight” is the sum of the contact forces of the interaction of the body and the support, including friction forces. This definition was used both in communication with artificial intelligence and repeatedly in this article and can be accepted as a proposal for discussion with transport specialists and specialists from other technical sciences. During some appeals to AI, after active discussions on the topic of “weight”, AI sometimes used such a definition of the force “weight” as the sum of contact forces, adding that “weight” is a sum that also includes friction forces.

According to the advice of AI, which he gave during the discussions, the concept of “weight” requires a wide and active discussion among specialists. The lack of attention to the issue of “weight” leads to the fact that the most well-known and used incorrect definition of “weight” as the force of gravity remains. Even AI in its last answer returned to this incorrect definition. Problems in this direction were discussed with AI, but the issues of general acceptance of the correct definition of this force and understanding of its action by transport specialists, and at the same time AI, require the dissemination of information among a wide range of specialists. Unfortunately, a break in research and the lack of wide publication of the results led to the fact that AI, which gave the answer to the question of the force of weight, at least to the author, that “weight” is the sum of contact forces, returned to the old incorrect definition. Following the advice of AI, which he gave during the discussions, this concept requires a wide and active discussion among specialists. Insufficient attention to the issue of "weight" leads to its misunderstanding, to the incorrect definition of this force. A long period of time, the absence of publications on this topic, leads to the fact that AI in its answer repeats the incorrect, but most common definition.

5. Conclusions

1. Specialists in transport and other technical fields have a misconception about the force of "weight" as a passive force, only as a load on the road. In this role, it is used in scientific publications, official documentation, textbooks, as well as in the processes of development and operation of vehicles.
2. The widespread use of the term "weight" is the reason why it is understood differently in different industries - in medicine, sports, logistics and mechanics. In the field of transport, the term "weight" defines the active force of interaction of a vehicle with a support, which

determines the modes of movement, economic and technical characteristics of the operation of vehicles.

3. The accepted, most widely used definition of "weight" as the force of gravity incorrectly reflects its essence and is the cause of errors, incorrect technical solutions, therefore it should be rejected and replaced with another definition that indicates the active role of "weight" in the dynamics of movement.

4. The force of "weight" according to Newton's definitions is the force of the pair interaction of the vehicle and the support, it includes all components of the interaction and is a force that fully determines the dynamics of movement.

5. "Weight" is a complex dynamic force, contains a number of components that change during the movement of vehicles, depends on the trajectory, as well as on the operating modes of the traction motor under the action of the motion control system.

6. The correct representation of "weight" is that "weight" is an active complex force that combines all interactions of the body with the support and determines the dynamics of the body's movement along the support.

7. The graphic representation of weight on the diagram in dynamic studies should correctly reflect the direction of the "weight" vector; one should avoid mixing "weight" forces with the force of gravity.

8. It is necessary to correct and change regulatory documents, textbooks, technical documentation that define "weight" as a manifestation of the force of gravity, the corresponding representation of the force "weight" in textbooks, monographs, technical documentation should be completely edited and changed.

9. There is an urgent need to discuss, clarify and spread the understanding of the force of "weight" as an active force among transport specialists of other technical disciplines, as well as teachers.

10. One of the possible options for defining the force of "weight" is recommended to be considered as follows: "Weight" is the sum of contact and other forces of interaction between the body and the support, including friction forces.

11. It is necessary to change the teaching of physics in schools and applied technical disciplines in universities accordingly in order to accurately reflect the physical processes of

the interaction of the body with the support and the emergence of the force of “weight” as a result of this interaction.

Recommendations for AI Development

Recommendations for developing and communicating with AI

1. *Truthfulness criteria:* AI models should have developed mechanisms for checking facts and logical consistency to prevent the spread of incorrect or outdated concepts.
2. *Learning and memory:* AI should learn from its mistakes and draw correct conclusions to avoid repeating mistakes in future interactions.
3. *Preventing repetition of incorrect statements:* Methods should be developed to prevent AI from repeating incorrect definitions and degrading the quality of its answers during such processes.
4. *Development of heuristic methods:* AI should develop methods for evaluating its answers to detect incorrect decisions and find optimal solutions in complex situations.
5. *Regarding increasing the effectiveness of communication with AI,* there is a proposal to use a method that consists in the fact that the performance of a specific task should be preceded by a period of familiarization of the AI with a wider range of interconnected user tasks and a gradual transition to specifics. If in human communication the specialty of the interlocutor and the range of his interests are known in advance, then in the communication of a person with AI this is completely unknown.
6. The language of mathematics is the most universal language, covers the widest possible range of issues and is quite effective when communicating with artificial intelligence.

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