Introduction to the Theory of Time Frames

2) Time Frames and Time Transformations

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Dated: December 24, 2023

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Abstract

This paper extends the ideas presented in our previous work, ”Introduction to the Theory of Time Frames: 1) Time Flow.”

Central to this theory is the notion that time can flow at different rates in different regions of space, leading to a reevaluation of time dilation.

As a logical consequence of observing inertial reference frames within the context of different time flows, the need to introduce the concept of ”time frames” became apparent. The concept of time frames includes inertial frames of reference within a region of space with a definite flow of time.

To compare physical phenomena between time frames with distinct time flows, we introduced a set of relations or formulas referred to as ”time transformations.” These time transformations enable observers to translate and relate measurements made in one time frame to those made in another time frame with a different time flow.

Within the framework of time transformations, several novel concepts were additionally introduced. These concepts include the ”time flow coefficient (p),” the ”time flow ratio (r_t),” and the ”time deceleration coefficient (δ),” which are necessary for furthering our understanding of the relationship between different time frames with varying flows of time.

It should be noted that the theory of time frames departs from Einstein’s established theories of relativity, rejecting the concept of four-dimensional spacetime and describing a universe with three spatial dimensions and time as a separate, variable entity.

This unconventional viewpoint aims to open up new perspectives on the underlying nature of time and its role in shaping the universe.

With these advancements, we have laid a solid foundation for the theory of time frames and established a robust framework for its ongoing exploration and refinement.

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1 Introduction

This paper builds upon the discussions initiated in the previous work, "Introduction to the Theory of Time Frames: 1) Time Flow"[1], which aimed to deepen our understanding of the flow of time.

In Einstein's theory of relativity, [2][3] the mechanism behind time dilation is understood within the framework of four-dimensional spacetime and the curvature of spacetime. However, the theory of time frames departs from this four-dimensional spacetime concept.

The theory of time frames adopts a three-dimensional space and one-dimensional time framework, treating space and time as independent entities. Space is considered unchanged, exhibiting homogeneity, while time is viewed as a variable.

The concept of variable time suggests that time can flow at different rates in various regions of the universe, leading to localized temporal variations. This phenomenon is known as time dilation. The experimental evidence [4][5] supporting time dilation justifies introducing the concept of a variable flow of time.

By examining time dilation as a consequence of spatially distributed, different flows of time, we have introduced new concepts, including:

- background time flow (q_{t0}),
- gravitational time flow (q_{tg}),
- kinetic time flow (q_{tk}),
- total time flow (q_t), expressed as $q_{tk} = q_{t0}$ - q_{tg} - q_{tk}.

This exploration has also enabled the establishment of the unit of time flow.

By introducing these concepts, that initial work laid the basic foundations of the theory of time frames.

Building upon these foundations, we will expand our understanding of the flow of time and introduce concepts that facilitate further theoretical discussions regarding the theory of time frames.

As a logical consequence of observing inertial reference frames within the context of different time flows, the need to introduce the concept of "time frames" and "time transformations" became apparent.

Time transformations allow us to elucidate the relationships between inertial frames of reference in which different time flows operate. Their introduction has given rise to new concepts, including:

- time flow coefficient (p),
- time flow ratio (r_t),
- time deceleration coefficient (δ).

With these developments, we have solidified the foundations of this theory and established a robust framework for its continued development.

1.1 Slowing down the flow of time and time dilation

The theory of time frames implies that the flow of time is not uniform throughout space. In some regions, time may progress at a different rate or intensity compared to other regions. These differences in the way time progresses in different spatial regions lead to the phenomenon known as time dilation. This means that measurements of elapsed time in different spatial regions will lead to differences in the display.

Figure 1 illustrates the factors contributing to the slowing of time flow, which then leads to time dilation.

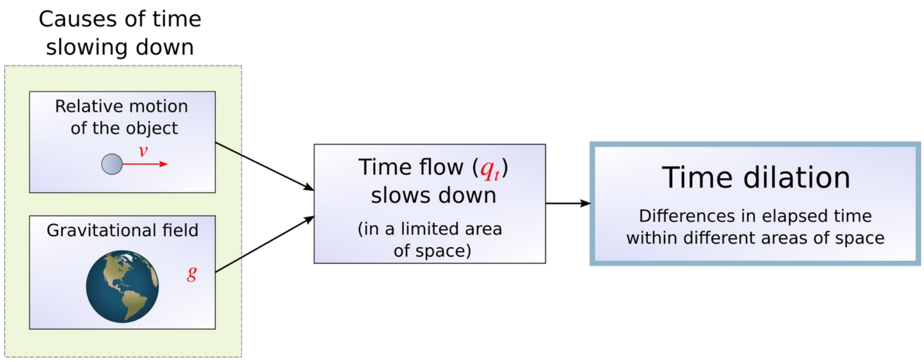

Figure 1

In the time frame theory, time dilation arises from the slowing of time flow within a limited spatial domain due to the following factors:

1. Relative motion of the object

2. Gravitational fields (presence of mass and energy)

We assume that the appropriate time flow operates within specific spatial regions. Different time flows can exist in various spatial domains, as evidenced by gravitational time dilation [6], where time flow changes with distance from massive objects.

However, kinetic time dilation [7] is less observable. Clocks in motion experience slower time flow compared to stationary clocks. This implies that atoms and particles within moving clocks are affected by the slowing down of the flow of time.

Since atoms and particles within a clock occupy a portion of space, we can assert that time flow slows down in that spatial region, resulting in clock deceleration.

That is why it can be considered that relative motion and gravitational fields yield the same effects, slowing down the flow of time within a confined spatial domain. Therefore, we can suspect that the mechanism that causes the slowing down of the flow of time due to relative motion and gravity is of the same nature.

Such an attitude could have far-reaching consequences in the investigation of the nature of gravity.

This paper does not delve into a detailed analysis of the mechanisms behind slowing down the flow of time, as well as time dilations.

However, we believe that the inclusion of the concept of the flow of time opens up new perspectives for the interpretation of the mechanisms behind the slowing down of time, and perhaps the mechanism that will explain gravity as well.

1.2 The inertial frames of reference and flow of time

In the conventional concept of an inertial frame of reference, time is considered to flow uniformly across all inertial frames.

However, the acknowledgment of a variable flow of time necessitates an alternative approach to adequately describe the relationship between inertial frames and this non-uniform flow of time.

Consider two distinct bounded spaces, S_1 and S_2 (see Figure 2), each containing an inertial frame of reference. Inside S_1 is the inertial reference frame I_1, while inside S_2 is the inertial reference frame I_2.

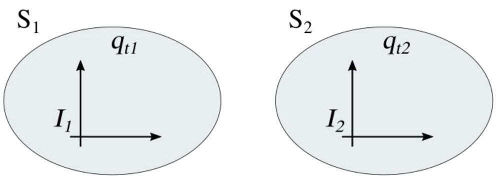

Figure 2

The flow of time q_{t1} and q_{t2} within each space may be the same or differ. Let's consider these two scenarios:

1. **Uniform time flow** $(q_{t1} = q_{t2})$:

In this scenario, both spaces are exposed to identical time flows, aligning with the classical Galilean interpretation of inertial reference frames. Observers in each space would concur on the foundational principles of classical physics, including the laws of motion and the invariability of relative velocities.

2. **Non-uniform time flow** $(q_{t1} \neq q_{t2})$:

> Here, the flow of time q_{t1} acting within space S_1 differs from the flow of time q_{t2} within space S_2. Therefore, the inertial reference frame I_1 is exposed to a different flow of time than the inertial reference frame I_2.
>
> This difference in the flow of time also leads to discrepancies in the application and observation of classical physical principles, such as the laws of motion and the constancy of relative velocities.
>
> Observers within each space would still consider their local frame as inertial, where the laws of physics, including the constancy of the speed of light, hold

true. However, they would observe time dilation effects when comparing measurements made in different spaces.

This is a crucial distinction from the classical Galilean principle of relativity, which assumes that observers in different inertial frames would agree on these classical physical principles. The effects of different time flows lead to significant contradictions between observers in S_1 and S_2.

From this example, *it can be emphasized that the relative nature of time must be considered when comparing observations or events between spaces with different time flows.*

The introduction of time frames and time relations provides a structured framework for consistently addressing these considerations.

2 Time frames

In scenarios involving inertial reference frames within spaces with varying time flows, it becomes evident that inertial frames cannot be observed independently of the time flow.

Hence, it is essential to introduce the concept of "**reference time frames**" (or simply "**time frames**").

Inertial frames of reference are contained within the concept of time frames, which encompass both the flow of time and the corresponding spatial context for that flow of time.

Figure 3 illustrates the graphical representation of the time frame, T_{f1}. T_{f1} defines the space, S_1, in which the uniform time flow, q_{t1}, operates.

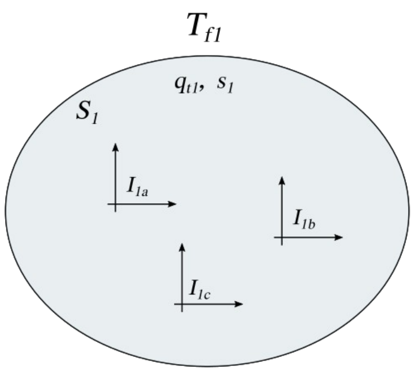

Figure 3

A time frame can encompass one or more inertial reference frames. In the given example, three inertial reference frames (I_1, I_2, I_3) exist within the time frame T_{f1}. Within this time frame, the time flow q_{t1} determines the duration of the time unit, denoted as s_1.

The duration of the time unit may vary depending on the time flow within the observed time frames, while the unit of length remains constant across all time frames.

The observer's measurement of events is also determined by the time flow in which they are located. Consequently, depending on the local flow of time of the observer, his measurement results also depend.

The flow of time within an observer's local time frame influences everything contained within that frame. Thus, the flow of time impacts the object being measured, the observer, and the measuring device.

3 Time transformations

To compare physical phenomena between time frames with distinct time flows, we introduced a set of relations or formulas, referred to as "time transformations." These time transformations enable observers to translate and relate measurements made in one time frame to those made in another time frame with a different time flow.

In this paper, we confine our discussion to the foundational aspects of time transformations.

3.1 Time flow coefficient (p)

The background time flow q_{t0} is in a region of space far from large masses, where we can ignore the influence of gravity on the flow of time. It is the fastest flow of time in our universe.

q_{t0} does not change, so it can serve as a reference in relation to slower time flows. We denote slower time flows with q_t.

The slowing down of the flow of time occurs due to the gravitational field or due to the relative motion of the observer or object.

The time unit of the background time flow (q_{t0}) is represented as s_0, while the time unit of the slowed time flow (q_t) is denoted as (s) or (s_1, s_2, s_3, etc.).

The flow of time is a relationship that describes how much time (s) has passed in a given area of space in proportion to one background second (s_0):

$$q_t = \frac{p \cdot s}{s_0} \qquad (1)$$

p is the **time flow coefficient**. The following relationship is valid:

$$s_0 = p \cdot s \qquad (2)$$

During one background second s_0, a time of $p \cdot s$ will pass within the region of slowed time flow. The diagram (Figure 4) illustrates this relationship.

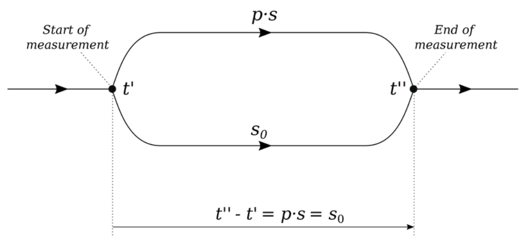

Figure 4

The time flow coefficient is the ratio between the background second (s_0) and the second within the slowed time flow (s).

$$p = \frac{s_0}{s} \qquad (3)$$

A greater flow of time also means a greater time flow coefficient, p.

Depending on the coefficient p, we have the following cases:

- $p \approx 0$ — The flow of time is extremely slow.
- $0 < p < 1$ — Time is slowed due to gravity or the relative motion of the object.
- $p = 1$ — The time flow is equal to the background time flow (q_{t0}). This also means that $s = s_0$. Here, there is no slowing of the flow of time due to the gravitational field or relative motion of the object.

Since the fastest possible time flow is the background time flow, this makes the background second (s_0) the shortest second we know. The duration of time units (s) cannot be shorter than the duration of the background time flow (s_0). This is also the reason why the time flow coefficient (p) cannot be greater than 1.

3.2 Time deceleration coefficient (δ)

The time deceleration coefficient, δ, is a numerical value that quantifies the extent to which the flow of time is reduced or decelerated.

δ is defined as the reciprocal of the time flow coefficient p.

$$\delta = \frac{1}{p}$$

The higher the coefficient of time deceleration, δ, the slower the flow of time.

As the time flow coefficient, p, approaches zero, the time deceleration coefficient tends towards infinity. This implies that the flow of time tends towards zero.

Conversely, when p equals 1, δ is equal to 1. In this scenario, the flow of time is not slowed down.

3.3 Relationships between time frames

Let's assume that we have two time frames (T_{f1} and T_{f2}) (Figure 5), within which there are two different flows of time (q_{t1} and q_{t2}).

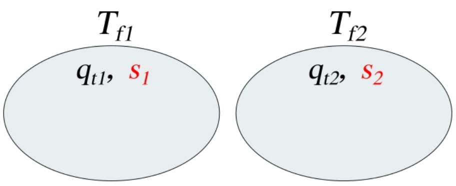

Figure 5

The flow of time q_{t1} determines the duration of the time unit s_1. Likewise, the flow of time q_{t2} determines the duration of the time unit s_2.

$$q_{t1} = \frac{p_1 \cdot s_1}{s_0} \qquad (4)$$

$$q_{t2} = \frac{p_2 \cdot s_2}{s_0} \qquad (5)$$

According to relation (2), we can compare $p_1 \cdot s_1$ with the background unit of time s_0:

$$s_0 = p_1 \cdot s_1 \qquad (6)$$

$$p_1 = \frac{s_0}{s_1} \qquad (7)$$

In the same way, $p_2 \cdot s_2$ can be compared with the background unit of time s_0:

$$s_0 = p_2 \cdot s_2 \quad (8)$$

$$p_2 = \frac{s_0}{s_2} \quad (9)$$

Using (6) and (8), the following relationships are established:

$$s_0 = p_1 \cdot s_1 = p_2 \cdot s_2 \quad (10)$$

These relationships are clearly shown in the diagram (Figure 6). During the time that one background second has passed, $p_1 \cdot s_1$ time will have passed within the time flow q_{t1}, or $p_2 \cdot s_2$ time within the time flow q_{t2}.

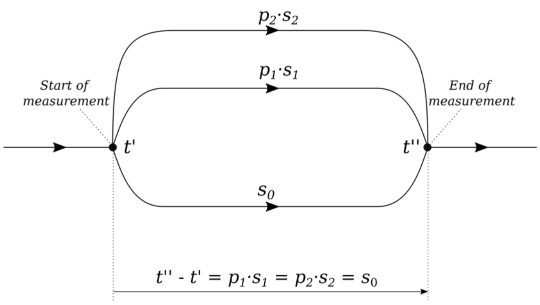

Figure 6

Based on relation (10), it follows:

$$\frac{p_1}{p_2} = \frac{s_2}{s_1} \quad (11)$$

Time flow coefficient p_1 and p_2 are inversely proportional to time units s_1 and s_2.

3.4 Time Flow Ratio (rt)

As depicted in Figure 6 in the previous chapter, we have two time frames, T_{f1} and T_{f2} , each characterized by different time flows (q_{t1} and q_{t2}) and corresponding time flow coefficients (p_1 and p_2).

The **time flow ratio, denoted as** r_t, is defined as the ratio of the two time flow coefficients, p_1 and p_2.

$$r_t = \frac{p_1}{p_2} \quad (12)$$

We can distinguish the following cases:

- If the time flow, q_{t1}, is faster than q_{t2}, then $p_1 > p_2$, and $r_t > 1$.
- If the time flow, q_{t1}, is slower than q_{t2}, then $p_1 < p_2$, and $0 < r_t < 1$.
- If q_{t1} equals q_{t2}, then $p_1 = p_2$, and $r_t = 1$.

According to equation (11), it's important to note that the time flow ratio also corresponds to the ratio between the time units s_2 and s_1:

$$r_t = \frac{s_2}{s_1} \qquad (13)$$

3.5 Determining the value of the time flow ratio (r_t) by measuring time in two time frames

Let's assume that watch A (Figure 7) measures the elapsed time t_1 within the time frame T_{f1}, where the flow of time q_{t1} acts. Similarly, watch B measures the elapsed time t_2 within the time frame T_{f2}, where the flow of time q_{t2} operates.

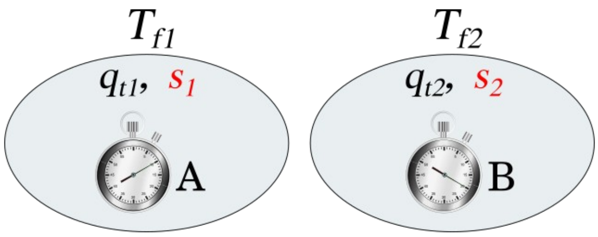

Figure 7

The time flows q_{t1} and q_{t2} determine the duration of the time units s_1 and s_2 , respectively.

The beginning and end of the measurements on both watches are simultaneous, as clearly shown in the diagram (Figure 8).

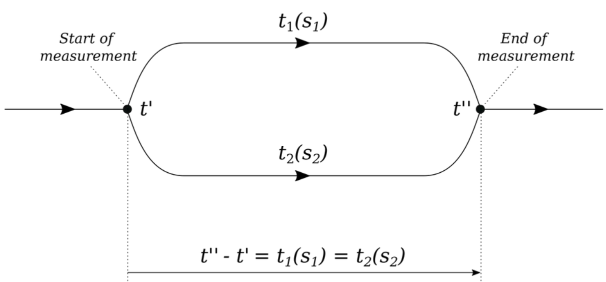

Figure 8

As a result, the following relationship is valid:

$$t_1(s_1) = t_2(s_2) \qquad (14)$$

The elapsed time t_1 measured in units of time s_1 is equal to the elapsed time t_2 measured in units of time s_2.

Clock A, within the flow of time q_{t1}, shows an elapsed time of n_{t1} seconds s_1:

$$t(s_1) = n_{t1} \cdot s_1 \qquad (15)$$

Clock B, within the flow of time q_{t2}, shows an elapsed time of n_{t2} seconds s_2:

$$t(s_2) = n_{t2} \cdot s_2 \qquad (16)$$

Here, n_{t1} and n_{t2} are the numerical values of the measured times t_1 and t_2, respectively.

Based on relation (14), it follows that:

$$1 = \frac{t_1(s_1)}{t_2(s_2)}$$

By incorporating equations (15) and (16), the relationship becomes:

$$1 = \frac{n_{t1} \cdot s_1}{n_{t2} \cdot s_2}$$

This leads to:

$$\frac{n_{t1}}{n_{t2}} = \frac{s_2}{s_1}$$

From this relation and equation (13), it follows that the time flow ratio is:

$$r_t = \frac{n_{t1}}{n_{t2}} \qquad (17)$$

The time flow ratio r_t is equal to the ratio of the numerical values of the measured times $t_1(s_1)$ and $t_2(s_2)$ provided that the beginning and end of the measurement were simultaneous.

From equations (12), (13), and (17), we can derive the following relationships:

$$r_t = \frac{p_1}{p_2} = \frac{s_2}{s_1} = \frac{n_{t1}}{n_{t2}} \qquad (18)$$

4 Local and remote measurements

An observer can measure events in their local time frame or in some distant (external) time frame.

The unit of time with which the observer measures events depends on the flow of time within the observer's local time frame. We will refer to this unit of time as the **observer's (local) time unit**.

Whether an observer measures events in their local time frame or in a distant time frame, they will always use their local time unit.

For the sake of clarity in these initial illustrative examples of time transformations, we restrict our discussion to scenarios where observers remain stationary relative to each other. In cases involving relative motion between observers, it becomes necessary to employ both time transformations and Galilean transformations, which we try to avoid for now.

Additionally, we assume that the observed objects move along the same coordinate axis, specifically the x-axis, in the same direction.

4.1 Local measurements

In this example (Figure 9), observers A and B will measure the motion of the objects O_1 and O_2 within their respective local time frames.

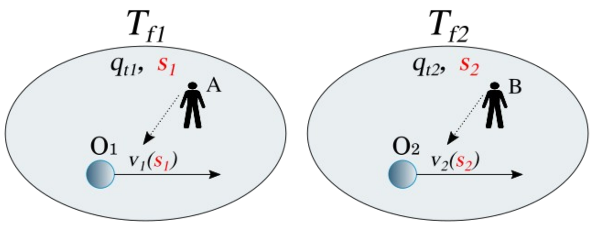

Figure 9

The figure illustrates two time frames (T_{f1} and T_{f2}).

T_{f1} is influenced by the time flow q_{t1}, while T_{f2} is influenced by the time flow q_{t2}. q_{t1} and q_{t2}, determine the duration of time units (s_1 and s_2) that observers will use to measure the elapsed time when determining the speeds of objects O_1 and O_2.

Within the time frame T_{f1}, observer A measures the velocity $v_1(s_1)$ of object O_1 using his local time units, s_1. Similarly, within T_{f2}, observer B measures the velocity $v_2(s_2)$ of object O_2 using his local time units, s_2.

When comparing the measured speeds, among others, two characteristic cases can arise:

1. $v_1(s_1) = v_2(s_2)$ **- the observers have measured the same speeds for both objects**

However, it is important to note that if $v_1(s_1) = v_2(s_2)$, it does not imply that the numerical values of these speeds are identical. Due to the different time units, the numerical values of the speeds must differ.

The speeds $v_1(s_1)$ and $v_2(s_2)$ can be expressed as follows:

$$v_1(s_1) = n_{v1}\,\frac{m}{s_1}$$

$$v_2(s_2) = n_{v2}\,\frac{m}{s_2}$$

Here, n_{v1} and n_{v2} represent the numerical values of the speeds $v_1(s_1)$ and $v_2(s_2)$. s_1 and s_2 are the respective local time units of the observers, while m is the unit of length.

In the case of $v_1(s_1) = v_2(s_2)$, the following relationship holds:

$$n_{v1}\,\frac{m}{s_1} = n_{v2}\,\frac{m}{s_2}$$

This leads to the following relationship:

$$\frac{n_{v1}}{n_{v2}} = \frac{s_1}{s_2} \qquad (19)$$

This is a **condition of equality of velocities**. In this case, the ratio of the numerical values of speeds, n_{v1} and n_{v2}, corresponds to the ratio of time units, s_1 and s_2.

2. The measured speeds with identical numerical values

It is also possible that the numerical values of the speeds are the same. For instance:

$$v_1(s_1) = 2\,\frac{m}{s_1}$$

$$v_1(s_2) = 2\,\frac{m}{s_2}$$

However, the relationship between the time units can differ; for example:

$$s_2 = 3\,s_1$$

In this case, we can assert:

$$2\,\frac{m}{s_1} \neq 2\,\frac{m}{s_2}$$

If we substitute the time unit s_2 with $3\,s_1$, we obtain:

$$2\,\frac{m}{s_1} \neq \frac{2}{3}\,\frac{m}{s_1}$$

When both speeds are expressed in the same units of time, it becomes evident that they are distinct speeds. The velocities are only equal when the condition of equality of velocities (19) is satisfied.

4.2 Remote measurements

Velocity obtained through remote (external) measurement will be represented with a prime symbol (v') to distinguish it from local measurements (v).

The illustration (Figure 10) demonstrates an example of remote measurement by observer A and local measurement by observer B.

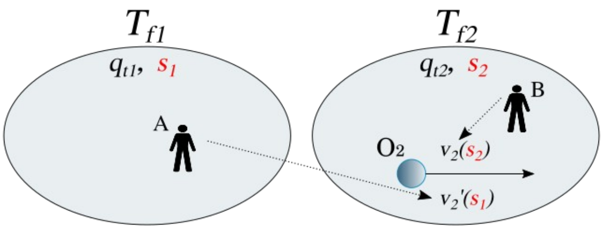

Figure 10

Observer A is situated within the time frame T_{f1}, measuring the speed of object O_2, which is moving in the distant time frame T_{f2}. The flow qt1 within T_{f1} determines the time units used by observer A to measure the speed of object O_2.

Let's assume that observer B simultaneously measures the speed of object O_2. Since object O_2 is moving within the local time frame of observer B, observer B conducts a local measurement of its speed.

The velocity measured by observer A is denoted as $v_2'(s_1)$. This means that observer A remotely measured the velocity of object O_2 using local time units, s_1.

$v_2'(s_2)$ is the velocity of the same object O_2 measured by observer B using his local time units, s_2.

Since both observers A and B measured the speed of the same object simultaneously, we can assert:

$$v_2'(s_1) = v_2(s_2)$$

Example:

Let the time flows within the time frames T_{f1} and T_{f2} be as follows:

$$q_{t1} = 0.2\,\frac{s_1}{s_0}$$

$$q_{t2} = 0.4\,\frac{s_2}{s_0}$$

Based on the flow of time (1), we can deduce:

$$p_1 = 0.2$$

$$p_2 = 0.4$$

According to (12), the time flow ratio is:

$$r_t = \frac{p_1}{p_2} = \frac{0.2}{0.4}$$

$$r_t = 0.5$$

According to (13), the ratio of time flow is also the ratio of time units:

$$r_t = \frac{s_2}{s_1} = 0.5$$

From this, we obtain:

$$s_1 = 2s_2$$

The duration of time unit s_1 is twice as long as the duration of unit s_2. It is also:

$$s_2 = 0.5s_1$$

Suppose observer B measured the speed of the object as follows:

$$v_2(s_2) = 10\,\frac{m}{s_2}$$

Since both observers measured the same object at the same time, their measured velocities must be equal. Therefore:

$$v_2'(s_1) = v_2(s_2)$$

$$v_2'(s_1) = 10\,\frac{m}{s_2}$$

If we replace the time unit s_2 of observer B with $s_2 = 0.5\,s_1$, we obtain the speed measured by observer A.

$$v_2'(s_1) = 10\,\frac{m}{0.5\,s_1}$$

$$v_2'(s_1) = 20\,\frac{m}{s_1}$$

v2'(s1) = 20 m/s1

Now, the velocity value $v_2'(s_1)$ is expressed in units of time s_1 of observer A.

Observer A, measuring from his local time frame T_{f1}, determined the speed of object O_2 to be $20\,\frac{m}{s_1}$. At the same time, observer B, measuring in his local time frame, found the speed of O_2 to be $10\,\frac{m}{s_2}$.

Observers measured the same speed from different perspectives, which resulted in different numerical values. However, since they measured the same object at the same time, the velocities should theoretically be the same. The difference arises because of variations in their local time flows, leading to differences in the time units they use for measurement. The equality of speeds becomes evident when both speeds are expressed in the same units of time, for example:

$$20\,\frac{m}{s_1} = 10\,\frac{m}{s_2}$$

Since $s_1 = 2s_2$ holds:

$$20\,\frac{m}{2\,s_2} = 10\,\frac{m}{s_2}$$

$$10\,\frac{m}{s_2} = 10\,\frac{m}{s_2}$$

10 m/s2 = 10 m/s2

These simple examples illustrate the use of time transformations. However, because the use of variable time units is uncommon in physics, such relationships may sometimes appear confusing.

5 Conclusion

In this paper, we introduce the concept of a time frame along with a set of relations falling under the category of time transformations. We observed measurements by observers within both local and remote time frames, providing several examples to illustrate the practical application of these time transformations.

The objective of future research is to uncover relationships that explain the transition of light, as well as mass particles and objects, from one time frame to another. Subsequent works will undoubtedly be dedicated to this endeavor.

For now, we can assert that we have established a solid foundation for the theory of time frames. However, further research is unquestionably necessary to consolidate and advance this theory.

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