

# The Theory of Relativity for dummies

## A totally different approach

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[Wikipedia](#) *Special principle of relativity: If a system of coordinates  $K$  is chosen so that, in relation to it, physical laws hold good in their simplest form, the same laws hold good in relation to any other system of coordinates  $K'$  moving in uniform translation relatively to  $K$ .*

Of course no one doubts this postulate, it follows directly from the Maxwell's equations. But, however, that **does not explain** why this is so.

## Space in two dimensions.

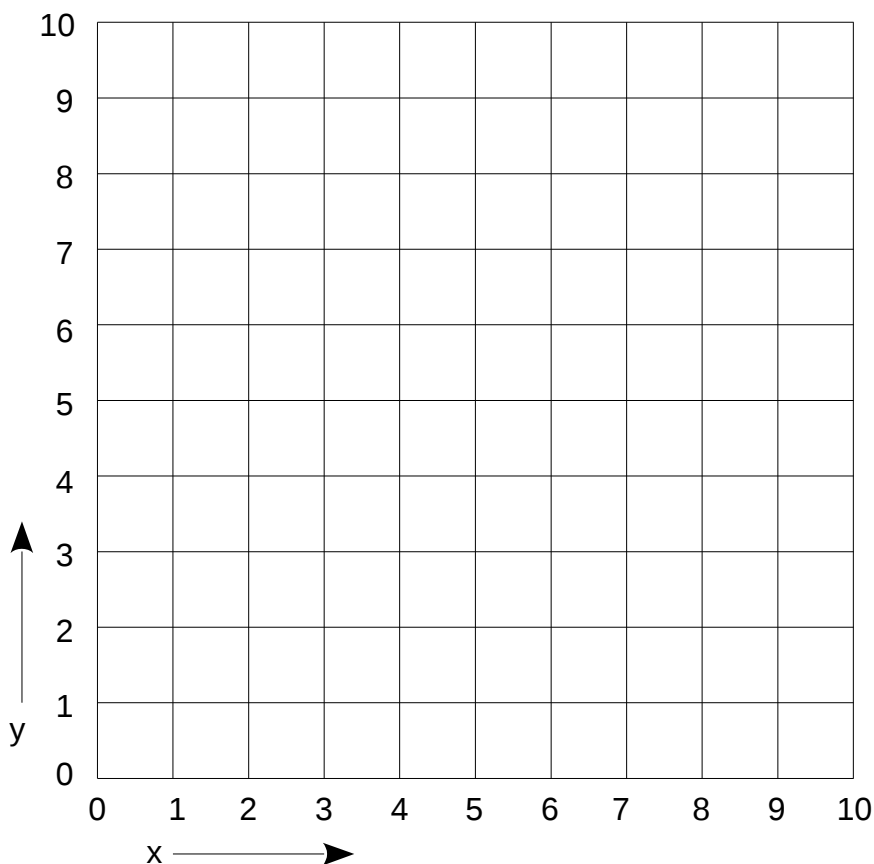
Imagine a two-dimensional space with an  $x$  and  $y$  axis. We do not use a third dimension in this example, but due to the symmetry the same is truth for the  $z$ -axis as for the  $x$  and  $y$ -axis.

In this space (the D-space) time does not exist as a separate dimension, but it is fully intertwined with the space, on the understanding that a distance of 300,000 km is equal to 1 second. It does not matter in what direction you travel this distance.

The D-space is different from the Minkowski-space where we are accustomed to. For example, the Minkowski-space has a separate dimension for time and a large part of the space is prohibited area. Speeds are limited to 300,000 km/s ( $c$ ).

In the D-space there is no prohibited area and speed is not defined.

For convenience we divide the  $x$  and the  $y$ -axis in seconds.

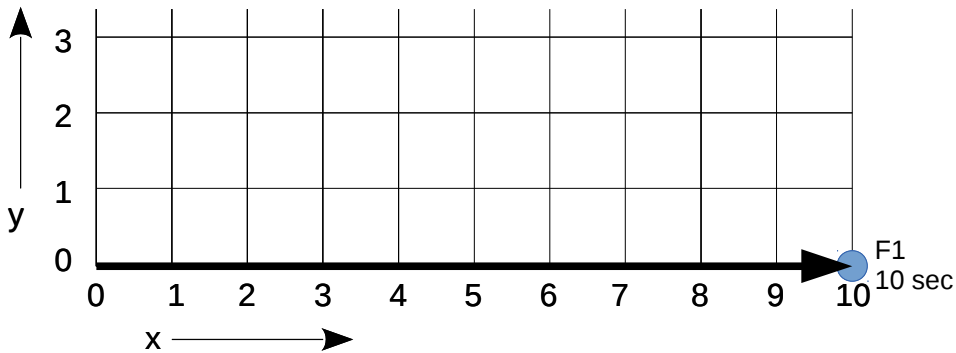


## Two kinds of particles

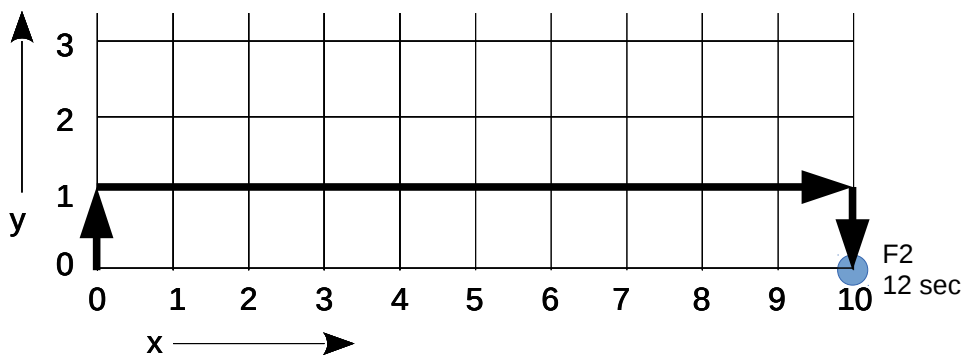
In this space, there are two kinds of particles. One type can only move in a straight line, such as a photon. The other type consists of elementary particles of matter.

### A photon

Suppose a photon travels a path that goes from 0.0 (x, y) to 10.0, then the photon traveled 10 seconds or 3,000,000 km.

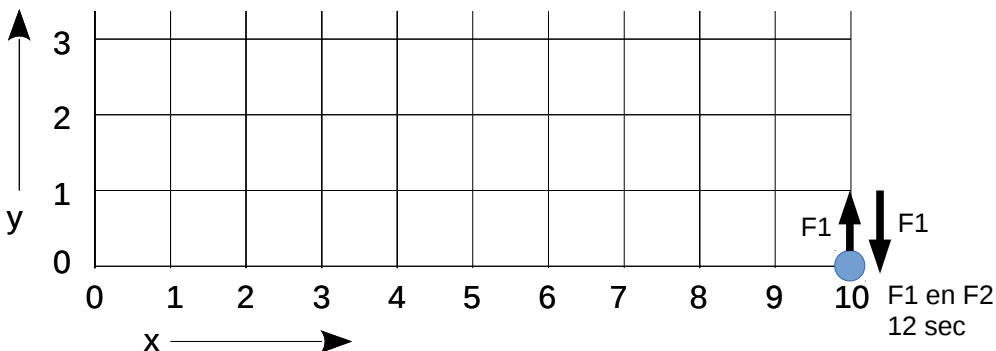


Suppose a second photon travels a path of 0.0 (x, y) to 0.1 to 10.1 to 10.0, than the second photon is located at the same spatial coordinates as the first photon. However, they can not see each other because the second photon has traveled a distance of 12 seconds.



You can compare that to two people who agree to meet under the Eiffel Tower in Paris. If they forget to mention a time then the chances are not very large they meet there. Only when they carefully agree about time, the meeting will take place.

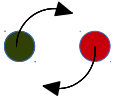
The first photon will meet the second photon again if it travels a distance of 2 seconds, for example by traveling from 10.0 to 10.1 and back to 10.0.



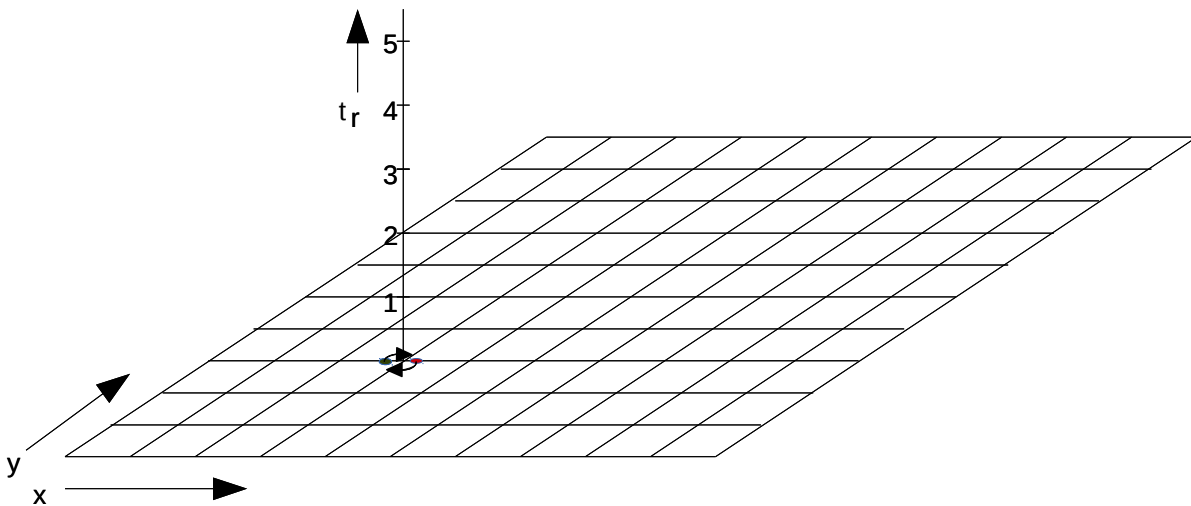
## An elementary particle of matter

Imagine the elementary particle of matter consists of two individual particles that rotate around a common point. Because these two particles attract each other, they hold each other in the same orbit.

Of course an elementary particle of matter is much more complicated, but this explanation satisfies for this model. Please note that these building blocks are very small. A neutron or proton contains three quarks and the size of a neutron, or a proton is already smaller than  $2 \cdot 10^{-15} m$ .



By rotating this particle also travels a distance. It is difficult to project this distance in the plane of the space. We therefore use an auxiliary axis which is perpendicular to the space dimensions  $x$  and  $y$ . Here  $t_r$  is the movement of the particle matter due to its rotation in seconds. Mind you, this is not a dimension, the motion of the particle of matter takes place entirely in the two-dimensional space.



Imagine an observer is constructed out of more than a billion times a billion times a billion of such particles. Of course he/she is unaware of the rotation of the elementary particles but it is clear that at a certain moment a certain time has elapsed.

## An observer and a photon

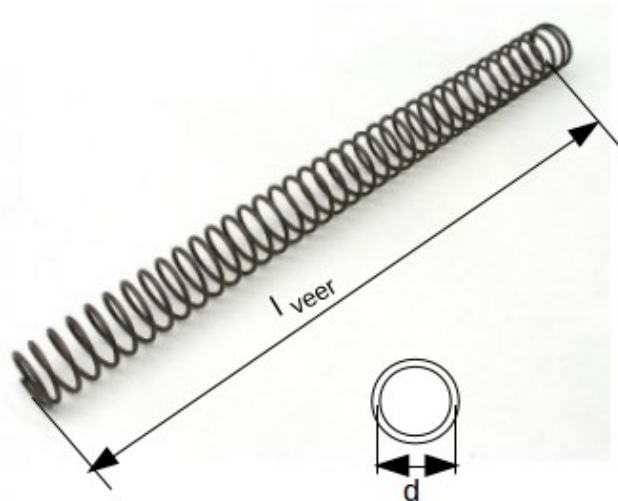
Suppose an observer shoots a photon to a mirror at a distance of 10. At that point it will be reflected. We assume that the observer knows that this mirror is at a distance of 10 seconds. To meet again, both have to bridge the same distance/time. If the photon returns to the observer, they have traveled 20 seconds (or 6,000,000 miles). The photon travels a straight path and the elementary particles of the observer by rotation.

The observer will now conclude that the photon has traveled the path of 6,000,000 km in 20 seconds and thus the photon has a speed of 300,000 km/s, called the speed of light  $c$ .

## An observer, a traveler and two clocks

In my next example, we assume we have an observer, a traveler and two clocks. Of course, the observer, the traveler and the clocks are composed of the same elementary particles of matter, and thus, all four travel with the same speed of time. When a second is elapsed for the observer, that is also the case for the two clocks.

The traveler travels a certain way in our D-space. He takes one clock with him and one clock stays at the observer. The elementary particles of the traveler and his clock travel a certain distance by rotating and by a linear movement. The total distance is not a straight count to gather. The distance is determined by rotation  $t_r$  and the linear distance  $t_l$  traveled. Coincidentally (but perhaps our creator intended this as well) that the total distance traveled is determined by  $t_t = \sqrt{t_r^2 + t_l^2}$  ([see here](#)). It does not matter what angle the plane of rotation makes with the linear movement.



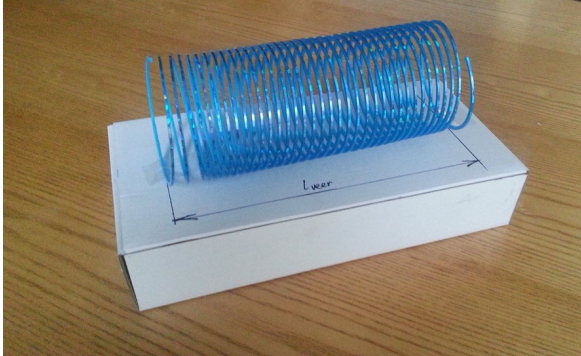
For example, the length of the wire ( $l_{wire}$ ), of which the spring is made is determined by the diameter  $d$ , the number of rotations  $n$  and the length of the spring  $l_{spring}$  (spring = veer) in such a way that

$$l_{wire} = \sqrt{(d \cdot \pi \cdot n)^2 + l_{spring}^2}$$

( $d \cdot \pi$  is the circumference of the spring)

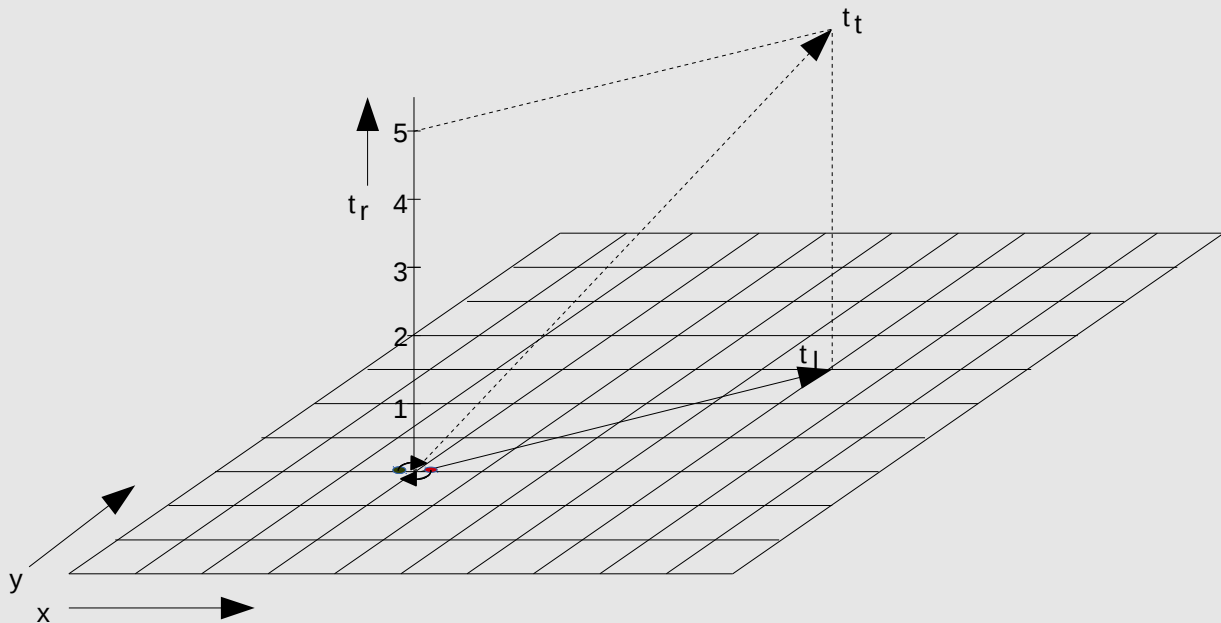
To make clear that the plane of rotation is not important, I made two pictures of the same spring. One rotates in a plane in a right angle of the length and the other almost in the same plane as the length of the spring.

Of course, the length of the wire from which the spring is made of, is equal in both cases.



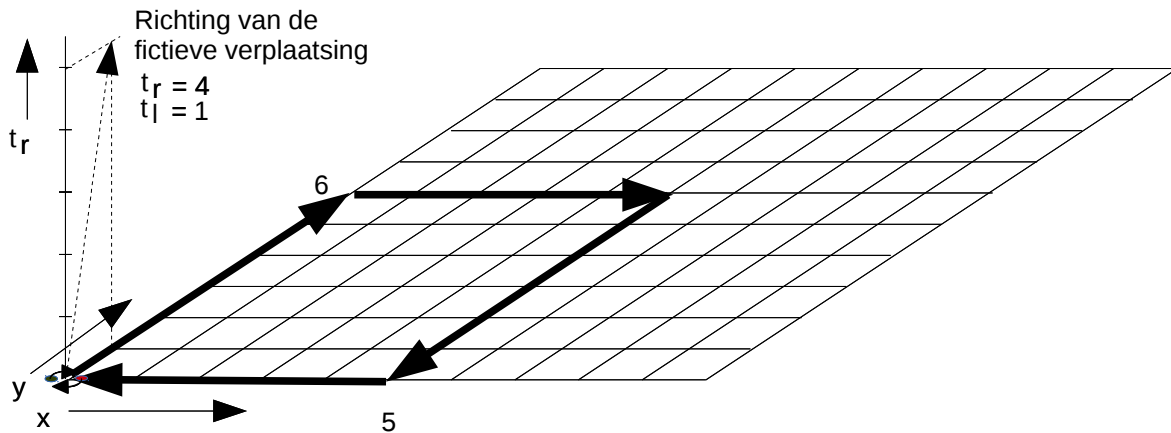
### The distance traveled by a particle matter

If we use an extra axis, perpendicular to the two-dimensional space, for the distance traveled by the rotation of the particle matter, then the length of the total distance traveled is equal to the hypotenuse of the triangle formed. Graphically it looks like this:



Again, the distance traveled is entirely through space. It is tempting to think that the  $t_r$ -axis does the same as the spatial axes as there is a symmetry  $t_t = \sqrt{t_x^2 + t_y^2 + t_r^2}$ . It seems that  $t_r$  has the same function as  $t_x$  and  $t_y$ , but that is more or less by coincidence.

Suppose a traveler travels a path of 0.0 to 0.6 to 5.6 to 5.0, and finally returns to the clock and an observer to 0.0 (coordinates are plotted before departure). In this example, the ratio between  $t_r$  and  $t_i$  is so that  $t_r=4$  when  $t_i=1$ , therefore the traveler will travel a distance of 300,000 km in 4 seconds, and interprets its speed as 75,000 km/s. In total the traveler travels a distance of  $22 \times 300.000 \text{ km}$  in  $88 \text{ sec}$ .



In total the traveler and his clock travels a distance by rotation and linear displacement of  $t_t = \sqrt{22^2 + 88^2} = 90,7 \text{ seconds}$  (all in seconds). The clock and the observer that stayed behind meet as they also have traveled 90.7 seconds in time. The clock of the traveler, however, displays 88 seconds.

*(The clock of the traveler will indeed go faster through time of space, but will therefore not run faster.)*

The observer interprets the speed of the traveler as  $\frac{6.600.000}{90,7} = 72.767 \text{ km/s}$ .

The observer and the traveler do not agree on time and thus the speed at which the traveler has bridged the distance, respectively (90.7 seconds and 72,767 km / s), and (88 seconds and 75,000 km/s).

*In this example, we assumed that the passenger did not need time to reach its speed. This is, in practice, of course, not feasible. Also, in this example, the distances are determined by the observer and the passenger before the time of departure. The traveler observes all distances different at the moment he is moving relative to the observer. More about this later.*

**Until now, it has been agreed that time, distance and speed are determined by the observer and not by the traveler.**

More in general  $t_t = \sqrt{t_l^2 + t_r^2}$  (see above).

(  $t_t$  is the total distance traveled,  $t_l$  is the linear distance traveled and  $t_r$  is the distance traveled by rotation.  
All distances in seconds)

$$\Rightarrow t_{\text{observer}} = \sqrt{t_l^2 + t_{\text{traveler}}^2}$$

$$\Rightarrow t_{\text{traveler}} = \sqrt{t_{\text{observer}}^2 - t_l^2}$$

$$\Rightarrow t_{\text{traveler}} = t_{\text{observer}} \sqrt{1 - \frac{t_l^2}{t_{\text{observer}}^2}}$$

$$\Rightarrow t_{\text{traveler}} = t_{\text{observer}} \sqrt{1 - \frac{t_l^2 \cdot c^2}{t_{\text{observer}}^2 \cdot c^2}} \quad (t_l \text{ is the distance in seconds and } t_l \cdot c \text{ the distance in km.)$$

$$\Rightarrow t_{\text{traveler}} = t_{\text{observer}} \sqrt{1 - \frac{v^2}{c^2}} \quad (v = \frac{t_l \cdot c}{t_{\text{observer}}}, \text{ the speed determined by the observer})$$

or  $t' = t \sqrt{1 - \frac{v^2}{c^2}}$  the formula from the special relativity.



## A few useful equations.

From the equation  $t_i = \sqrt{t_i^2 + t_r^2}$  more equations can be derived.

$$\Rightarrow t_{observer}^2 = t_i^2 + t_{traveler}^2$$

$$\Rightarrow \frac{t_{observer}^2}{t_i^2 \cdot c^2} = \frac{1}{c^2} + \frac{t_{traveler}^2}{t_i^2 \cdot c^2}$$

$$\Rightarrow 1/v_i^2 = 1/c^2 + 1/v_e^2 \quad \begin{array}{l} v_i \text{ is the speed of the traveler according to the observer} \\ v_e \text{ is the speed of the traveler according to the traveler} \end{array}$$

$$\Rightarrow 1/v_e^2 = 1/v_i^2 - 1/c^2 \quad \text{thus} \quad v_e = \frac{1}{\sqrt{1/v_i^2 - 1/c^2}} \quad \text{or} \quad v_e = \frac{v_i}{\sqrt{1 - v_i^2/c^2}} \quad (\text{A})$$

$$\Rightarrow 1/v_i^2 = 1/v_e^2 + 1/c^2 \quad \text{thus} \quad v_i = \frac{1}{\sqrt{1/v_e^2 + 1/c^2}} \quad \text{or} \quad v_i = \frac{v_e}{\sqrt{1 + v_e^2/c^2}} \quad (\text{B})$$

$$\Rightarrow v_i^2 = \frac{v_e^2 c^2}{c^2 + v_e^2} \quad \Rightarrow \quad v_i^2/c^2 = \frac{v_e^2/c^2}{1 + v_e^2/c^2}$$

$$\Rightarrow 1 - v_i^2/c^2 = \frac{1 + v_e^2/c^2}{1 + v_e^2/c^2} - \frac{v_e^2/c^2}{1 + v_e^2/c^2}$$

$$\Rightarrow \sqrt{1 - v_i^2/c^2} = \frac{1}{\sqrt{1 + v_e^2/c^2}} \quad \text{of} \quad \sqrt{1 - v_i^2/c^2} \cdot \sqrt{1 + v_e^2/c^2} = 1 \quad (\text{C})$$

(A) is useful if you want to replace  $v_i$  by  $v_e$  .

(B) if you want to replace  $v_e$  by  $v_i$  .

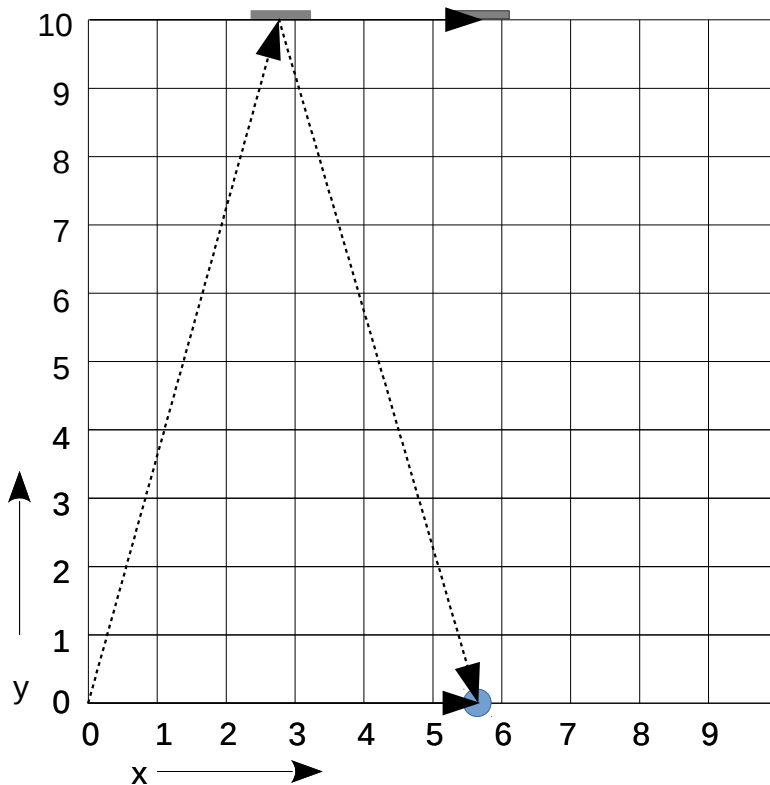
(C) if you want to replace  $\sqrt{1 - v_i^2/c^2}$  by  $\frac{1}{\sqrt{1 + v_e^2/c^2}}$  Or vice versa. Because both are frequently found in this combination.

## An observer and a mirror with a uniform speed.

What if the observer and the mirror travel with a uniform speed a distance through space. Does that affect there perception?

In many publications a test is done as an example with a passenger on a train that moves relative to an observer on the platform.

In our example, we will give the observe from a previous example a uniform speed along the x-axis, as well as the mirror. The x-axis is therefore the platform.



The photon and the observer occur both on  $t_x, 0$ .

The time that the photon has bridged is in a total  $t_f = 2 \cdot \sqrt{10^2 + (t_x/2)^2} = \sqrt{20^2 + t_x^2}$

The time the observer has bridged  $t_w = \sqrt{20^2 + t_x^2}$  (Think about the tr-axis  $t_t = \sqrt{t_l^2 + t_r^2}$ )

Both will meet again because both are in the same time/space. The clock of the observer is at 20 seconds and he will still interpret the speed of the photon as  $c = 300.000 \text{ km/s}$ .

## Conclusion

If the observer does not have a point of reference it is impossible for him to determine by what kind of uniform speed he moves through space. In fact: If there is a reference point it is impossible to determine whether the reference point or he or both move in space. **It is impossible to assign point for which it is true that it is absolutely in rest.**

Conversely, any point that is not experiencing acceleration may be taken as a reference point.

**The position of a particle in the time/space is completely defined by its space coordinates and the distance traveled in that coordinate system by the particle.**

The coordinate system associated with a reference point that is not accelerating is called an inertial frame.

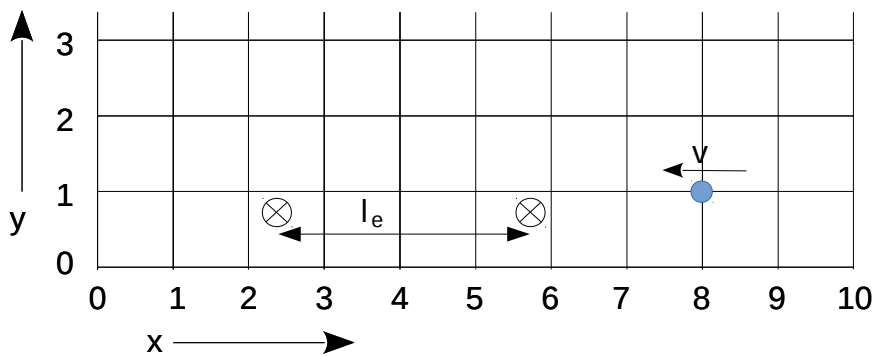
# Lorentz-Fitzgerald Contraction

[Wikipedia](#): Length contraction was postulated by George FitzGerald (1889) and Hendrik Antoon Lorentz (1892) to explain the negative outcome of the Michelson-Morley experiment and to rescue the hypothesis of the stationary aether (Lorentz-FitzGerald contraction hypothesis).

Eventually, Albert Einstein (1905) was the first to completely remove the ad hoc character from the contraction hypothesis, by demonstrating that this contraction did not require motion through a supposed aether, but could be explained using special relativity, which changed our notions of space, time, and simultaneity.

If an object with a certain length and speed is approaching an observer and needs some time to pass - than from the fact that there is the agreement that time, distance and speed are determined by the observer - the observer observes a shortening in the direction of movement.

In the following example, we place two beacons in our own inertial frame. These beacons are equipped with a radio and a lamp. We now proceed with a missile to a point far from these beacons and then return. We fly with a certain constant speed along these beacons.



On the basis of the radio stations from these beacons we determine our speed  $v_i$ . It will take us some time  $t$  in order to pass the two beacons. On basis of these data, we can now determine the distance between the beacons  $l_i = \frac{v_i}{t}$ . However, we know from previous calculations that our measurement is distorted by the fact that, by bridging a certain distance, we also bridge a certain time. The actual speed at which we fly through the coordinate system is  $v_e$ . For this speed applies  $l_e = \frac{v_e}{t}$ .

$$\text{Thus } \frac{l_i}{l_e} = \frac{\frac{v_i}{t}}{\frac{v_e}{t}} \text{ or } l_i = \frac{v_i}{v_e} \cdot l_e$$

$$v_e = \frac{1}{\sqrt{1/v_i^2 - 1/c^2}} \quad (\text{A})$$

$$\text{And thus } l_i = v_i \cdot l_e \sqrt{\frac{1}{v_i^2} - \frac{1}{c^2}} = l_e \sqrt{1 - \left(\frac{v_i}{c}\right)^2}.$$

# Relativistic energy

For a particle that we are accelerating from 0 to a speed of  $v_i$ , the kinetic energy can be expressed as  $E_k = \int F dx = \int \frac{dp}{dt} dx = \int \frac{dp}{dt} v_i dt = \int v_i dp$

for  $p$  applies  $p = \frac{m}{\sqrt{1 - (\frac{v_i}{c})^2}} \cdot v_i = m \cdot v_e$  ([Wikipedia](#) en page 6)  
 $m$  is the so-called rest mass.

For  $v_i$  applies  $v_i = \frac{v_e}{\sqrt{1 + \frac{v_e^2}{c^2}}}$  (page 6) or  $v_i = \frac{v_e \cdot c}{\sqrt{c^2 + v_e^2}}$

The above integral can now rewritten as:

$$E_k = mc \int_0^{v_e} \frac{v_e}{\sqrt{c^2 + v_e^2}} dv_e = mc \left[ \sqrt{c^2 + v_e^2} \right]_0^{v_e}$$

Finding the primitive function of the integral is mainly a matter of trying. The more you do it the faster you find the solution. Also you can solve the integral with Wolfram online integrator ([see here](#))

If you've solved in the past this differential  $\frac{dy}{dx}$  ofth  $y = \sqrt{p+qx+rx^2}$  an finding the primitive function of the above integral is an easy task.

Differential solved using the chain rule:

$$y = \sqrt{p+qx+rx^2} \quad u = p+qx+rx^2 \quad \text{so} \quad y = \sqrt{u}$$

$$\frac{dy}{du} = \frac{1}{2\sqrt{u}} \quad \text{and} \quad \frac{du}{dx} = q+2rx$$

$$\frac{dy}{du} \cdot \frac{du}{dx} = \frac{dy}{dx} = \frac{q+2rx}{2\sqrt{p+qx+rx^2}} = \frac{q/2+rx}{\sqrt{p+qx+rx^2}}$$

In our case:  $p=c^2$ ,  $q=0$  en  $r=1$

Between the boundaries  $v_e$  and 0 :

$$E_k = mc \sqrt{c^2 + v_e^2} - mc^2$$

In fact, this solution is already close to the equation  $E = mc^2$  because in fact the kinetic energy is equal to the total energy

$$E_{tot} = mc \sqrt{c^2 + v_e^2}$$

minus the energy at rest which is equal to

$$E_{rest} = mc \sqrt{c^2 + 0} = mc^2$$

The equation shows that the contribution of  $v_e$  is equal to the contribution by rotation  $v_r = c$ .

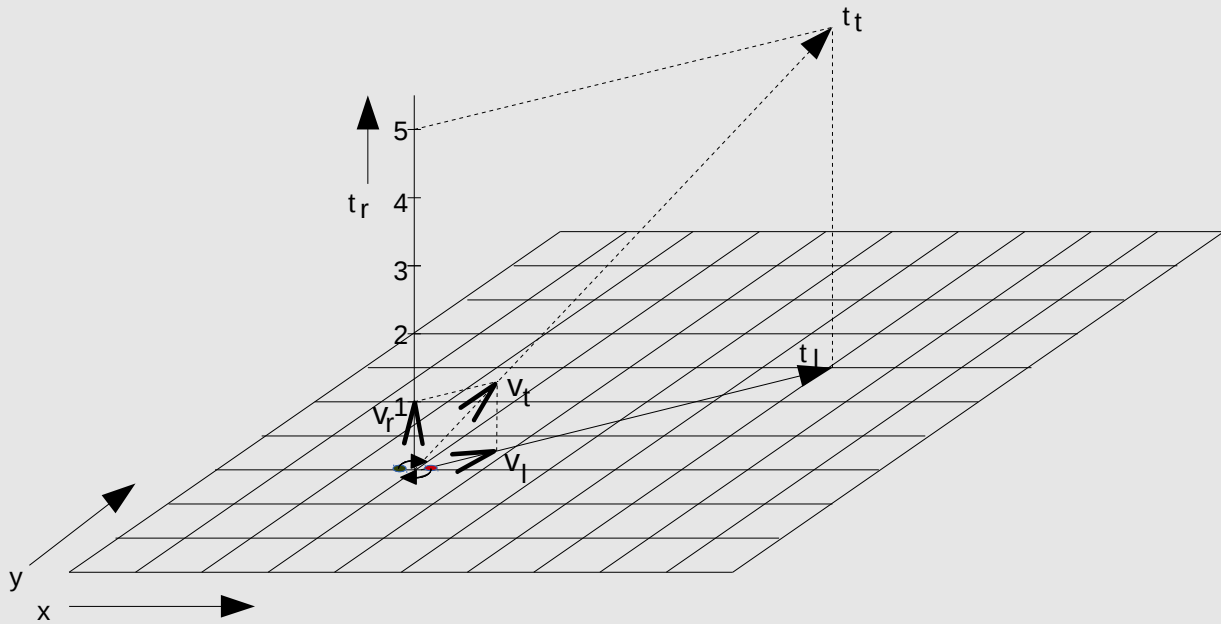
The equation  $E_k$  can be rewritten for  $v_i$  as:

$$E_k = mc \sqrt{c^2 + v_e^2} - mc^2 = mc^2 \sqrt{1 + \frac{v_e^2}{c^2}} - mc^2$$

$$\Rightarrow E_k = mc^2 \left( \frac{1}{\sqrt{1 - v_i^2/c^2}} - 1 \right) \quad (\text{Wikipedia})$$

## The energy of a particle of matter

If we compare the speed by rotation  $v_r$  of the particle of matter on a secondary axis perpendicular to the two-dimensional space, then the length of the total energy is equal to the hypotenuse of the triangle formed. Graphically it looks like this:



$$E_{tot} = mc \cdot v_t = mc \sqrt{v_r^2 + v_l^2}$$

## To be continued.

In this article/discussion I will show that it is better for a good understanding of the theory of relativity to take more distance from observation to interpret the observation data. In addition, the theory of relativity can be better understood.

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