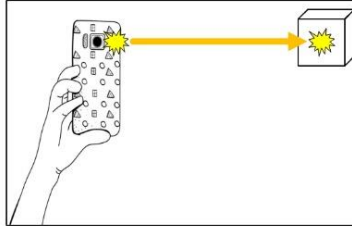


# A No-Math-Needed Explanation of Time Dilation

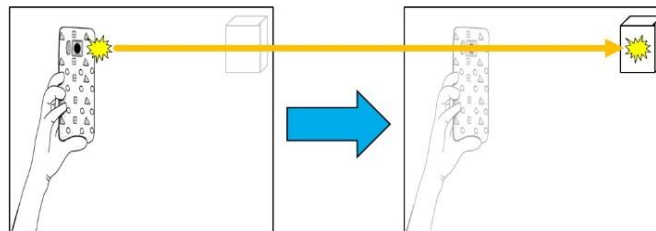
Terry Bollinger

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## Light delay when the phone and box are at rest



## Light delay when the phone and box are in motion



**Figure 1.** The root cause of time dilation is getting into a race with light.

Here's a no-math-needed way to understand why time must stop if you travel at lightspeed. First, accelerate your ship to its final velocity. It makes no difference if you accelerate quickly or slowly, so don't worry about that.

Next, take out your smartphone and ask it to find the distance to an object 5 feet in front of you. Your phone sends out a pulse of light that travels 1 foot (2.54 cm) every billionth of a second (one nanosecond). Thus, the round-trip time to and from the object is 10 nanoseconds, which your phone tells you means the object is 5 feet away. Your phone also behaved as a clock since you knew 10 nanoseconds (10 ns) have passed.

However, someone watching this from the outside sees a very different story.

Like you, they see the light pulse leave your phone and then move forward at lightspeed. However, unlike you, they also see the object moving *away* from your light pulse at close to lightspeed. It's a race! The faster you and the object move, the longer the light pulse takes to complete what you interpret as 5 ns to reach the box.

The closer you get to light speed, the longer it takes for light to catch up with the object. In principle, it could take a million years for your light pulse to cover the tiny gap from your phone to the object in front of it — and if you go exactly at light speed, the light pulse *never* reaches the object. In that situation, you appear frozen to the outside observer since you cannot complete even 5 nanoseconds of your clock time.

The exact math is a bit more complicated since there is also a change in length and because the light coming back arrives quicker instead of slower. But it's always the slowdown in the light in the forward direction that is the root cause of time dilation — and all you need to understand is the concept of a race in which one car always wins.

[1] T. Bollinger, *A no-math-needed explanation of time dilation*. Comment on: S. Hossenfelder, *Time Stops at the Speed of Light. What Does that Mean?*, Sabine Hossenfelder (YouTube) 2024, 0422 [Apr. 22] (2024). <https://youtu.be/vqwLKLc4gMg&lc=UgyGEv9FTKyW8Ku3FIB4AaABAg>