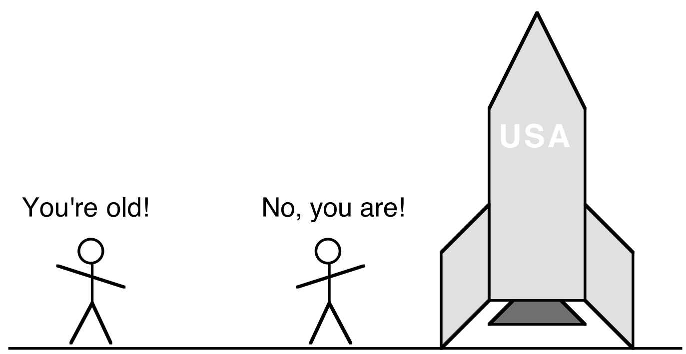
Paradoxes

There was, to put it mildly, a bit of a shift in our understanding of space, time and matter as a result of Einstein's theories. As with any radical new idea, there was a lot of controversy and give and take as science wrestled not only with the basic mathematics of relativity, but the overall implications. As part of this initial processing of relativity, there were a few famous "paradoxes" that were developed to try and discredit Einstein's theories. We will look at two of them now. It will be your job to try and figure out why these are not really paradoxes and how they do not prove relativity wrong.

The Twin Paradox

One of the basic tenants of relativity is that time is relative – and that there is no test to determine if you are at absolute rest or moving with a constant velocity. Remember when we first derived the equation for time dilation we stressed that you never noticed your clock doing anything strange – it was always the other person's clocks that were slowed. As the name implies, this paradox involves a set of twins.

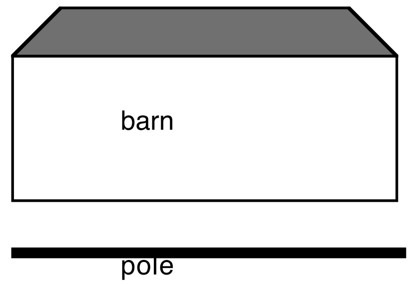
Twin A stays on the earth, while the twin B takes off at relativistic speeds on a long journey. When B returns back to earth, what happens? From A's reference frame, B was traveling at very high speed and so should have experienced time dilation, so A would have "seen" B aging slower, resulting in B not aging as much as A. However, from B's point of view, B's clocks never changed, and would have argued that A was the one traveling at high speeds away from them, so that A should have experienced the time dilation – so A should not have aged as much as B. So what happens when B gets back to earth and steps out of the space ship? Is A older than B or is B older than A? How can both statements be true? Oh no, relativity must be wrong!



Can you figure out how to explain this? If it helps, it turns out that in fact, the twin who stayed behind will have aged more than the twin who went on the trip. Why?

Paradoxes

The Barn and Pole Paradox
The second equation we derived was length contraction. Again, we stressed that when two objects pass each other, each object "sees" the other as being shorter in the direction of travel, while they remain "normal." This is a classic paradox around length contraction.

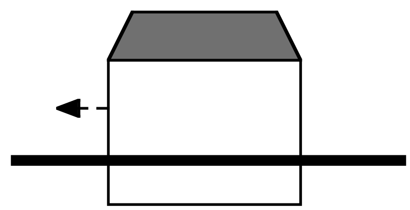


Imagine there is a barn with doors at each end and a pole and that the pole and the barn have identical proper lengths. That means, that when they are sitting next to each other they are the exact same length. Now, open both doors of the barn and have the pole travel at high speed through the barn. From the barn's reference frame, the pole is moving and so the pole will appear to be length contracted. Therfore, from the barn's point of view, the entire pole will fit inside it for a brief amount of time, and in fact, if the doors were fast enough, one could imagine literally closing both sets of doors at the same time for the brief time that the pole was inside the barn – making sure to open the doors just before the pole gets to the back door. Seems reasonable as far as a thought experiment, so what is the big deal?

The problem occurs when one thinks about the above scenario from the pole's point of view. The pole insists it is at rest, since it is in an inertial reference frame. The pole sees the barn rapidly coming towards it. So the pole sees the barn undergoing length contraction, so the pole sees a shorter barn pass over it. Clearly, the barn doors cannot be closed at the same time as the pole never even perceives itself as fitting in the barn at all!

barn's reference frame

pole is length contracted



pole's reference frame

barn is length contracted

Try and explain this one! If it helps, it turns out this paradox isn't really about length contraction.