



# CAN YOU Believe it?

WITH ASSOCIATE PROFESSOR DEREK LEINWEBER

## Time to ponder

We all know it's Einstein's greatest idea. But what actually is it?

**W**E tend to think of time as flowing at a steady rate. One second happens . . . once a second. But this is not always the case. Why is it a well-established observation that a clock moving at high speeds will be seen to run slow?

In fact, this phenomenon has been tested with extremely accurate atomic clocks flown on aircraft and satellites around the Earth.

Now, it's fairly easy to understand why a moving clock must run slow. It all follows from the fact that the speed of light is constant.

It is always measured to be the same – regardless of the speed of the light source.

This might seem a little strange.

After all, if you bowled a cricket ball at 100km/h from a train moving at 100km/h, you would expect it to move at 200km/h over the ground. But not so for light.

The speed of light emerging from your car's headlights is always the same; parked or not.

Consider a pulse of light aimed up towards a mirror that sends the light back down to a detector. When the light is received, another light pulse is emitted. We'll define the tick of the clock to be the time it takes for light to travel from the source to the mirror and back again.

Next, consider the same clock moving to the side at high speed. Now the light pulse from the source must be aimed diagonally to hit the mirror and reflected diagonally again to hit the detector. The path is longer.

Since the speed of light is unchanged, the time it takes to travel up to the mirror and back is longer. The time for each tick is longer and therefore the moving clock will run slow.

Particle physicists use this fact to perform experiments on short-lived particles. By creating the particles at a speed close to the speed of light, the particle "clocks" are observed to run slow enough to extend their life long enough to be studied.

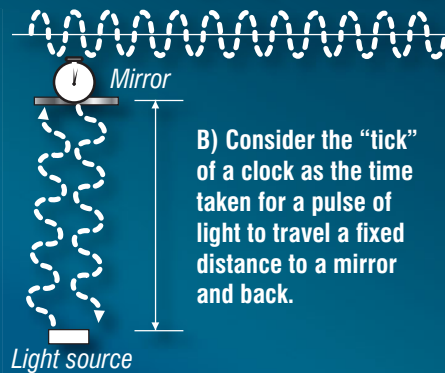
But wait, it gets better.

If we were to ride with the clock moving at high speed, we would be certain that time is passing as normal. This is because we would be slowed down just like the clock. All the electrochemical processes of the body are mediated by the speed of light - just like the tick of the clock.

Now here's where it gets a bit tricky.

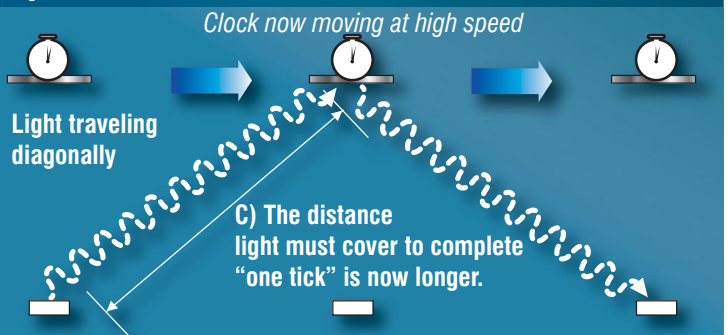
Suppose, as we ride with the moving clock at a constant speed, we see an identical clock stationary on the ground. We could argue that we are actually stationary and should observe

### Relatively speaking



A) The speed of light is constant, regardless of the speed of its source. The rate at which time flows, however, is not constant.

B) Consider the "tick" of a clock as the time taken for a pulse of light to travel a fixed distance to a mirror and back.



C) The distance light must cover to complete "one tick" is now longer.

the passing clock on the ground to be running slow. And we'd be right. This is a central point of Einstein's Theory of Special Relativity.

So whose clock is truly running slow?

It all comes down to who does the acceleration to speed up and then slow down to allow the comparison of clocks. And this is the subject of Einstein's General Relativity. The bottom line is that accelerated clocks run slow.

Now you might think this is all esoteric science irrelevant to our everyday life, but it is not. The flow of time is central to the computations behind the Global Positioning System (GPS). University of Adelaide physicist Dr Rod Crewther points out that because the signals are travelling at the speed of light, even the smallest timing errors create huge errors in distance. If one neglects the fact that satellite clocks run faster in their high orbit, then one encounters an error of 10,000m every day.

The implications are fascinating: An astronaut could be on a space ship approaching the speed of light. During the mission, the astronaut would perceive time passing normally. But the astronaut would return to Earth aged only slightly, while their partner may have aged tremendously. Obviously families should travel together - as they did in *Lost in Space* - but I suggest you leave Dr Smith at home.

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