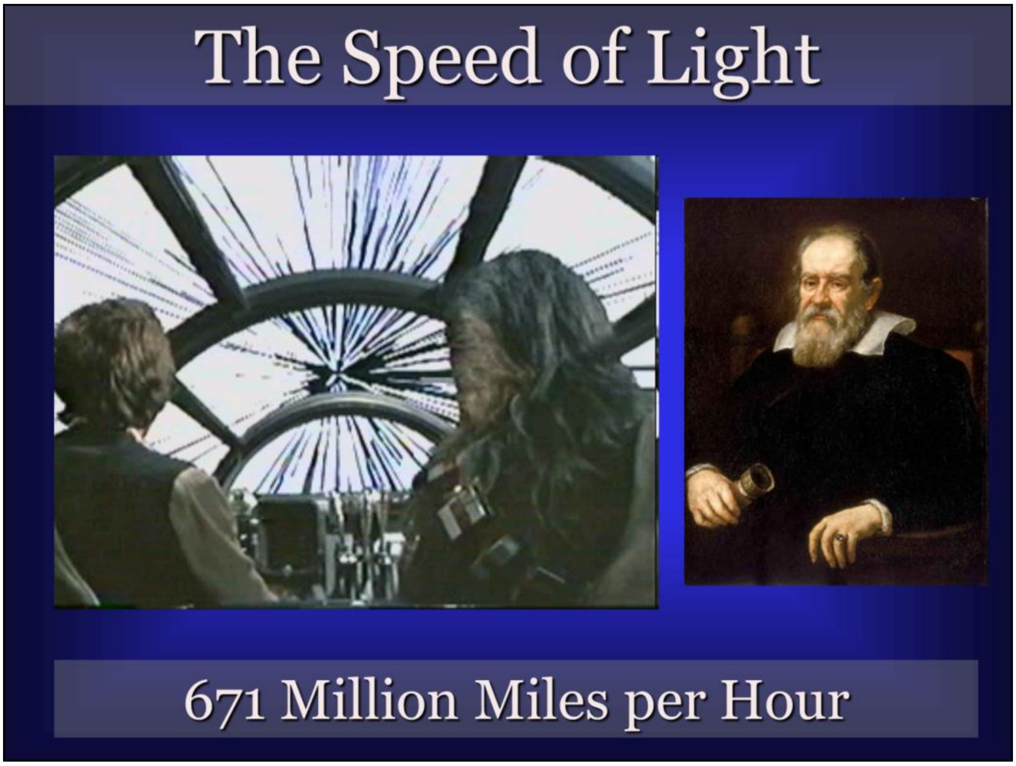
Special Relativity



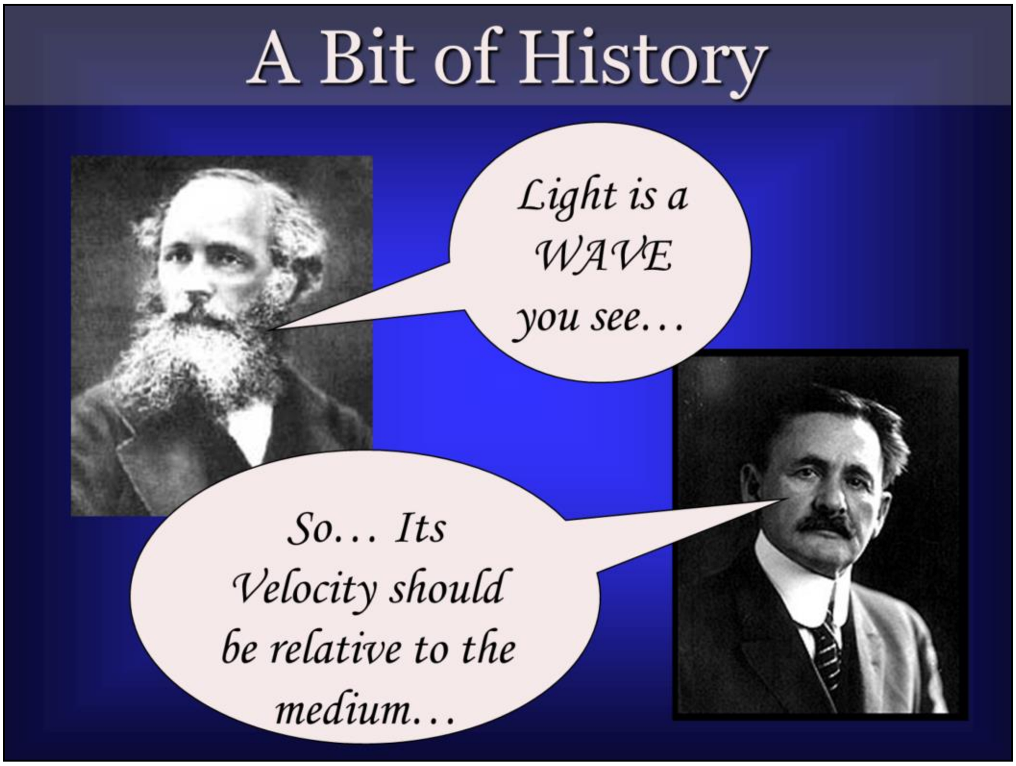
The speed of light is the “Cosmic Speed Limit” according to Albert Einstein.

It’s REALLY fast though!

186,000 miles per second!

Galileo TRIED to measure it using lanterns on a mountain top.

Conclusion: REALLY fast! If not instantaneous. At least 10 times faster than sound.

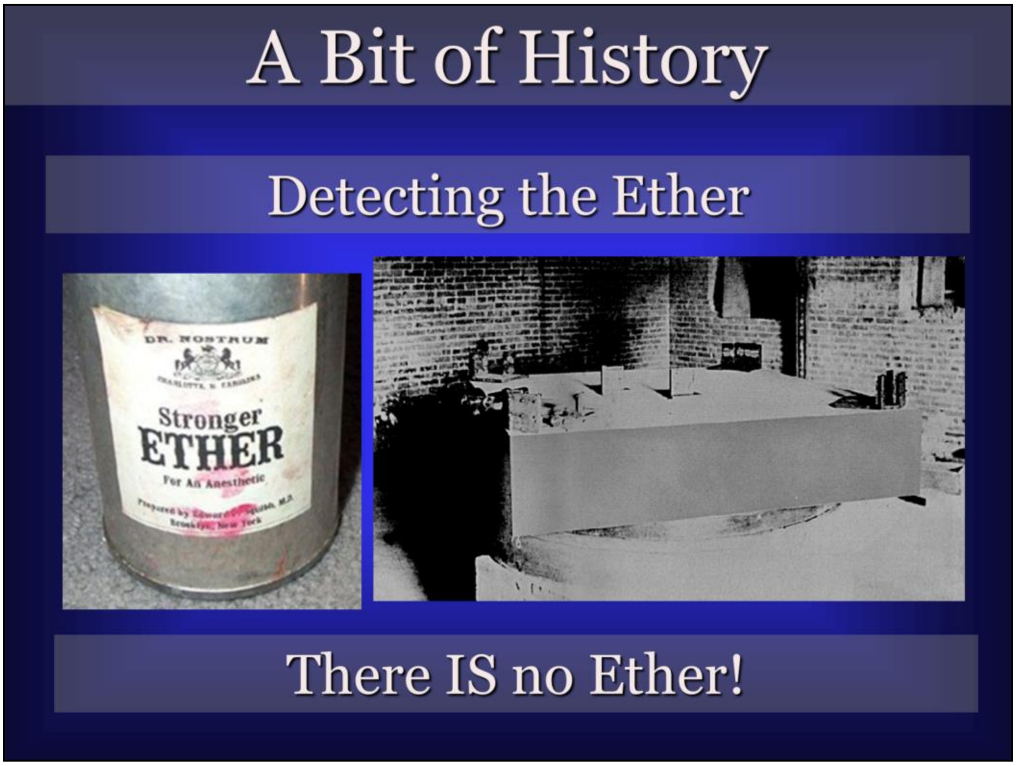


Maxwell said Light acts like a wave.

Well, waves aren't objects in their own right like baseballs… They only make sense in the context of a MEDIUM.

Thy propagate (move) with a velocity that's relative to the MEDIUM.

So… If you are in motion with respect to the medium, you will add YOUR velocity to the propagation velocity.



So… If light is a wave, it MUST have a medium!

That medium for light was called the Ether.

The Earth has a LOT of different motions…. So, at some point it must have a velocity relative to the Ether…

Michelson and Morley set out to find our velocity with respect to the ether.

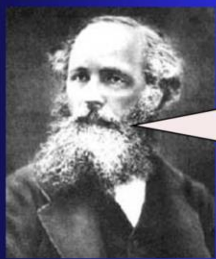
They determined that it was zero. We appear to be at rest with respect to the ether. All the time. NO matter which way we're going.

But the Earth is clearly in motion around the Sun… and the Sun is in motion through the galaxy…

AND the Earth is spinning on its axis. It's unpossible for us to be at rest with respect to the ether.

A Bit of History

If theory disagrees with experimental evidence…



I'm pretty sure this is right

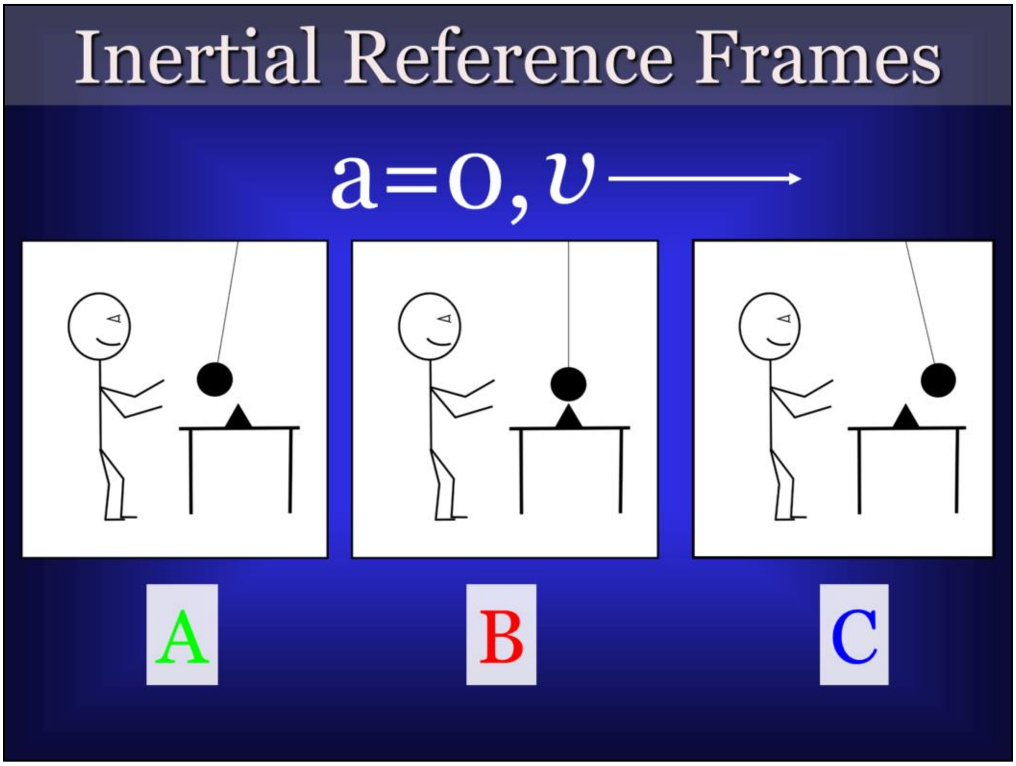
$$\nabla \cdot \mathbf{D} = 4\pi\rho$$

$$\nabla \times \mathbf{H} = \frac{4\pi}{c}\mathbf{J} + \frac{1}{c}\frac{\partial \mathbf{D}}{\partial t}$$

$$\nabla \times \mathbf{E} + \frac{1}{c}\frac{\partial \mathbf{B}}{\partial t} = 0$$

$$\nabla \cdot \mathbf{B} = 0$$

What's wrong with Maxwell's theory of light?



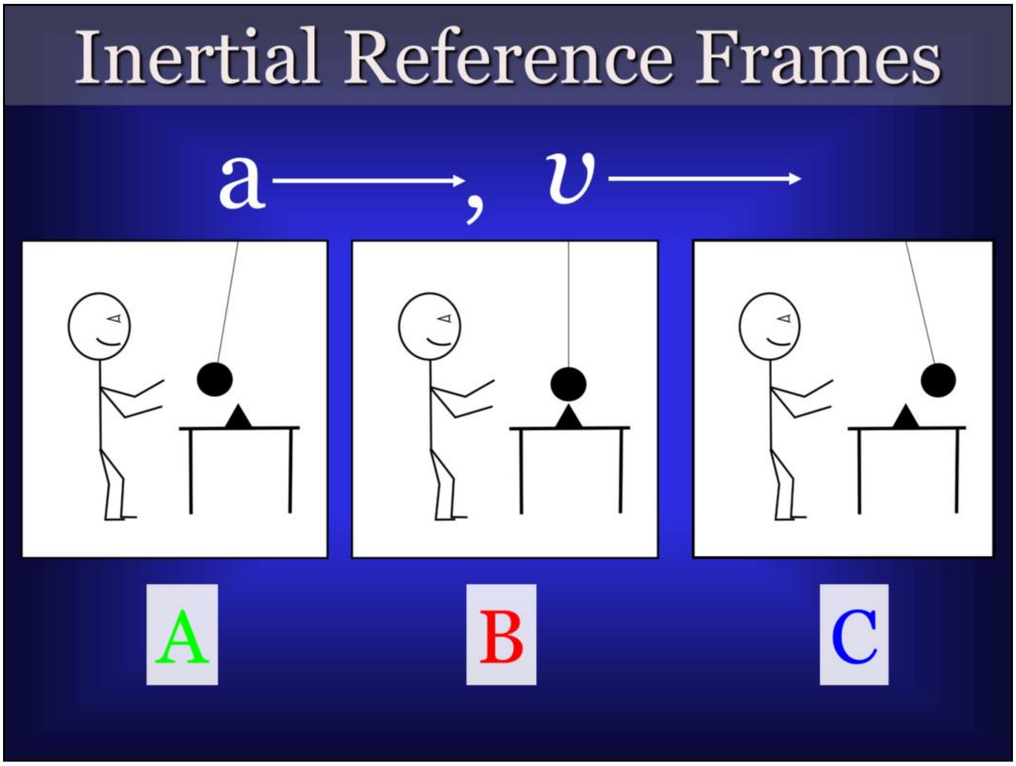
We are only considering NON-ACCELERATING frames of reference accelerating.

If you are in a box moving at a fixed velocity, there are no experiments that detect your motion.

You have to look out a window to see the outside world.

There are ways to detect that you are accelerating.

Answer is B



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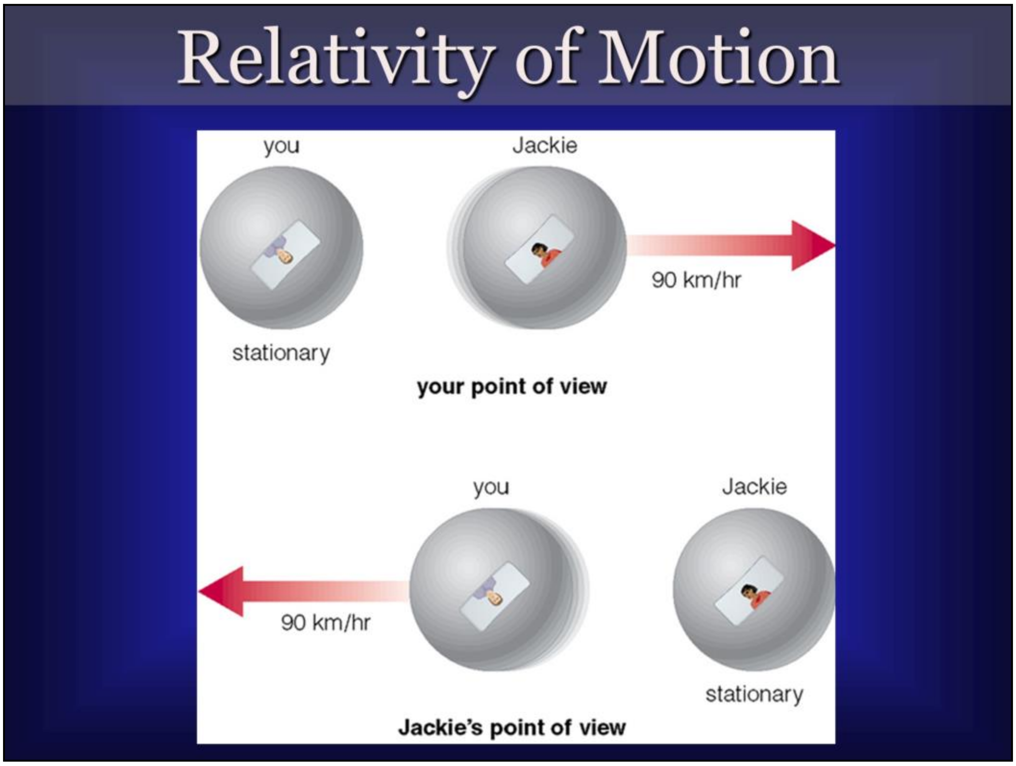
Answer is A

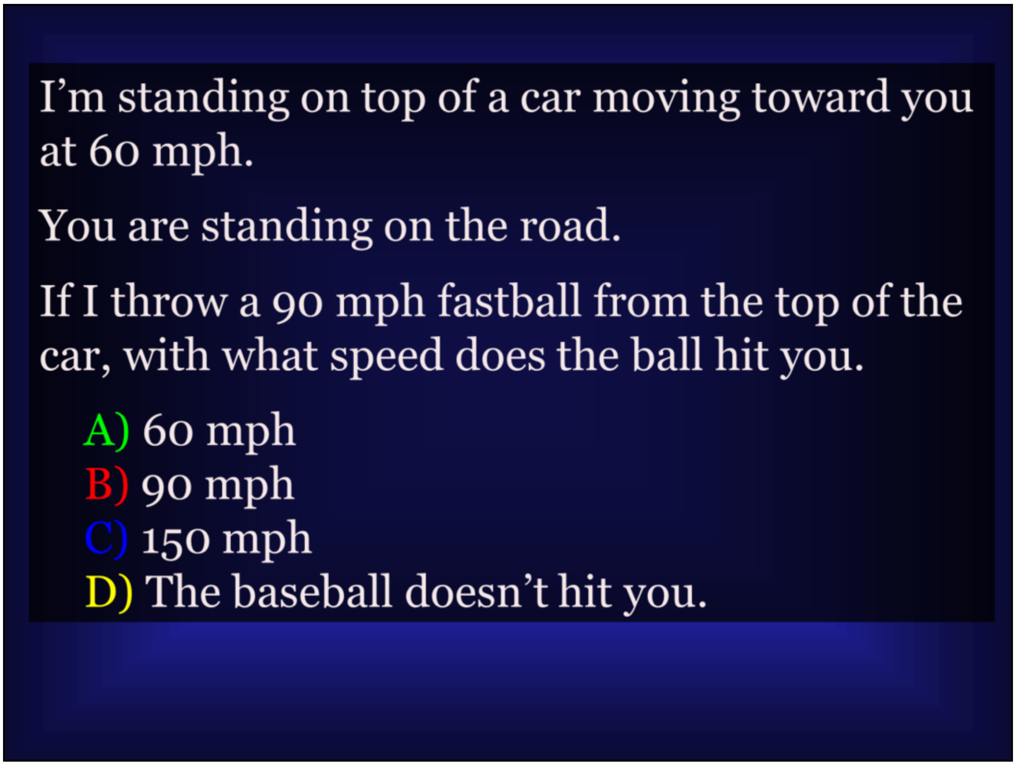


There is no absolute rest frame.

If there are two objects in the Universe with a constant velocity *relative* to one another,

It is valid to pick either of them as a frame of reference.

This only works with CONSTANT velocity. If one is *accelerating*, we could determine that.



Let’s remove the Earth and use me as a frame of reference

I see you rushing toward me at 60 mph.

I throw the baseball and see it rushing away from me at 90 mph

I see that the relative speed between you and the ball is 60 + 90 = 150 mph

Let’s use you as the frame of reference

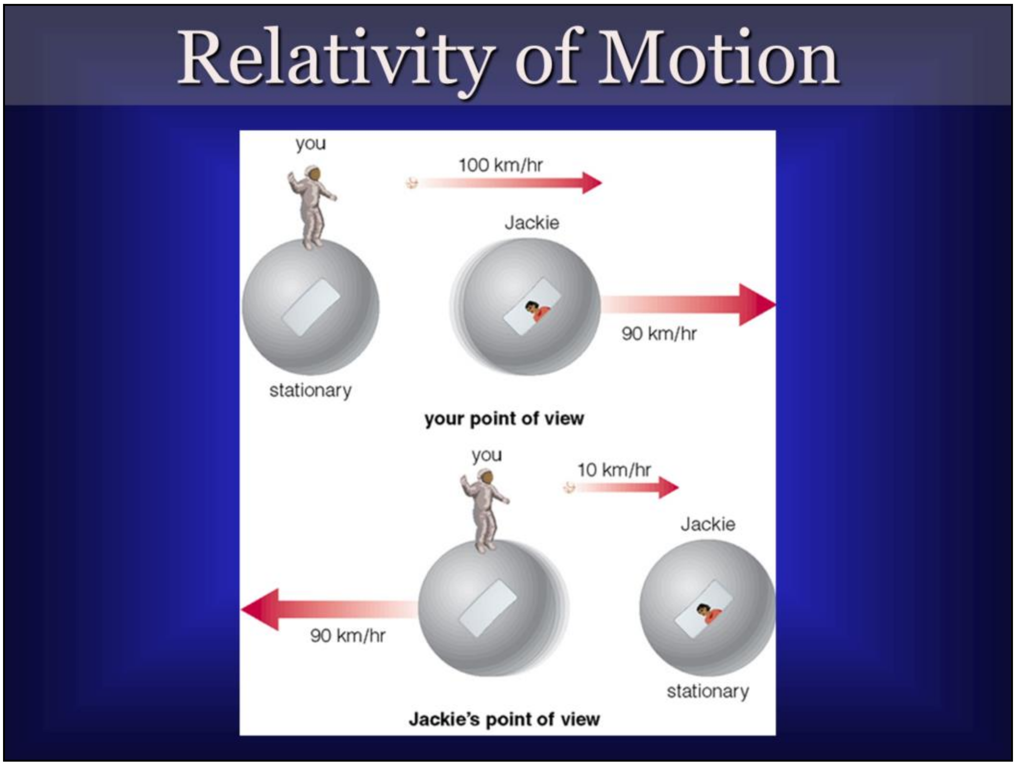
You see me rushing toward you at 60 mph

Before I throw the ball, it too is rushing toward you at 60 mph

I add an EXTRA 90 mph to the ball with my throw.

You see it coming toward you at 60 + 90 = 150 mph

Answer is: C



What if you try to fly away from me?

From my point of view

You are moving at 90 km/hr away from me.

I throw the ball at 100 km/hr towards you

I see the relative speed between you and the ball is 100 – 90 = 10 km/hr

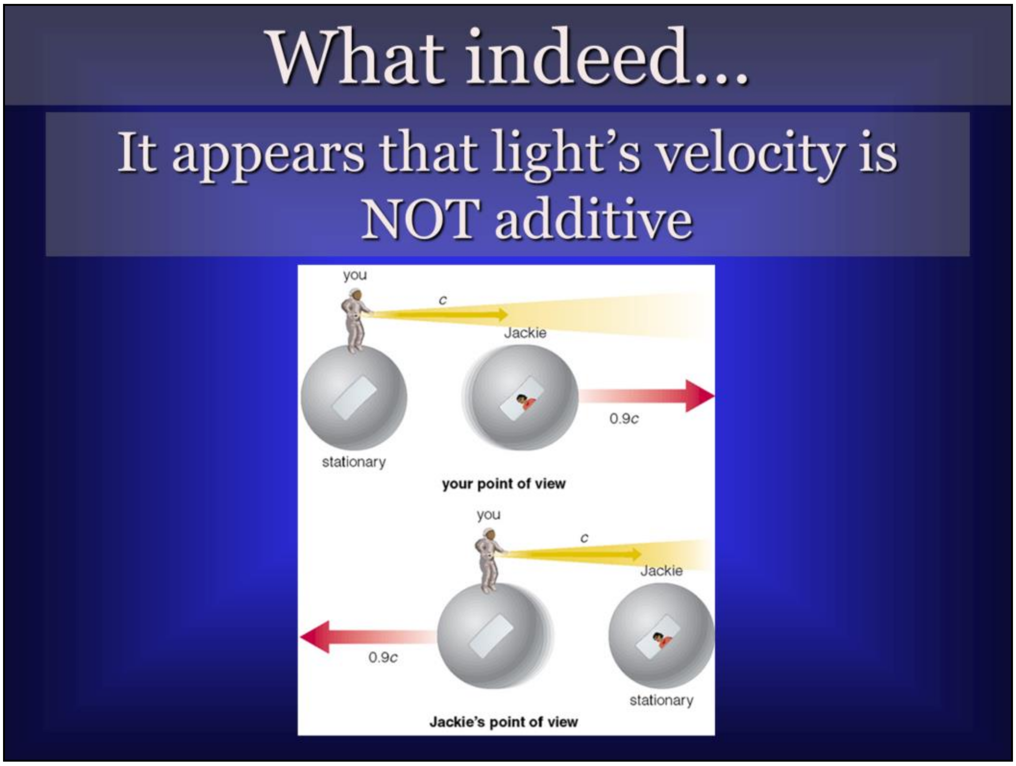
From your point of view

I'm moving AWAY from you at 90 km/hr

Before I throw the ball, it is moving away from you at 90 km/hr too

I "add" 100 km/hr to the balls velocity.

You see it coming towards you at 10 km/hr

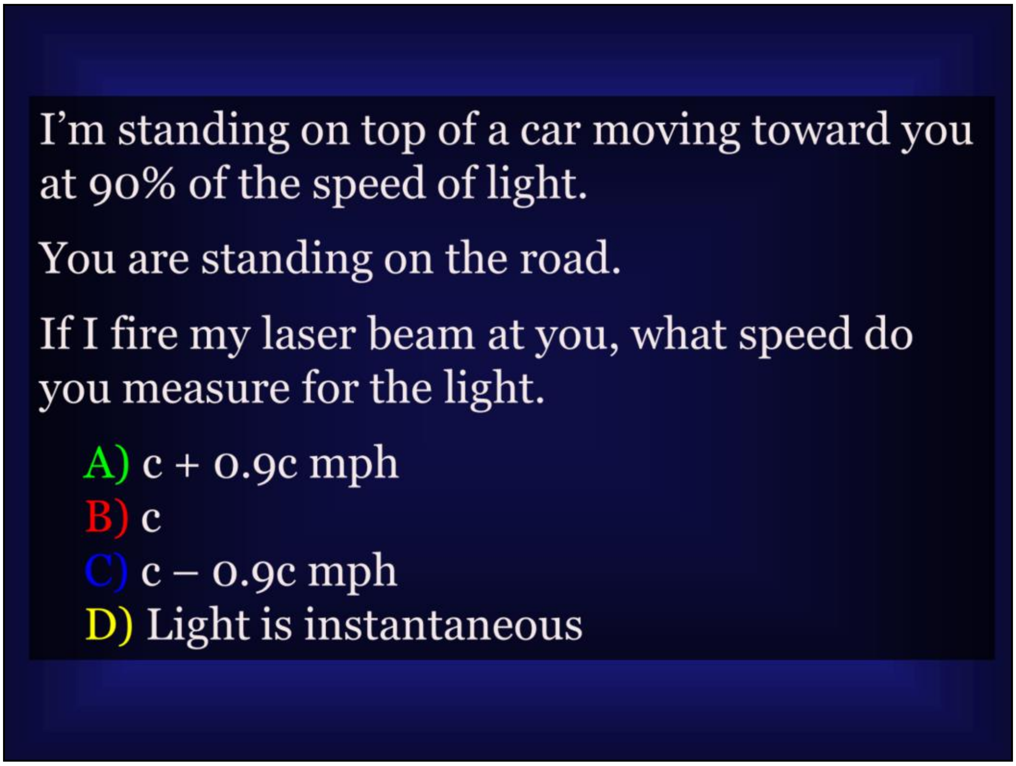


A beam of light is fired from the roof of a car moving at 100 mph:

With respect to the roof of the car, the light is going c (where c is the speed of light, 186,000 miles per second)

With respect to the Earth, the light is going c.

Very different from the baseball case. The speed of light is ALWAYS THE SAME FOR ALL OBSERVERS.


I'm standing on top of a car moving toward you at 90% of the speed of light.
You are standing on the road.
If I fire my laser beam at you, what speed do you measure for the light.
A) c + 0.9c mph
B) c
C) c – 0.9c mph
D) Light is instantaneous

C

I’m standing on top of a car moving toward you at 90% of the speed of light.

You are standing on the road.

If I fire my laser beam at you, what speed do I measure for the light.

A) c + 0.9c mph
B) c
C) c – 0.9c mph

Answer B

I'm standing on top of a car moving toward you at 90% of the speed of light.

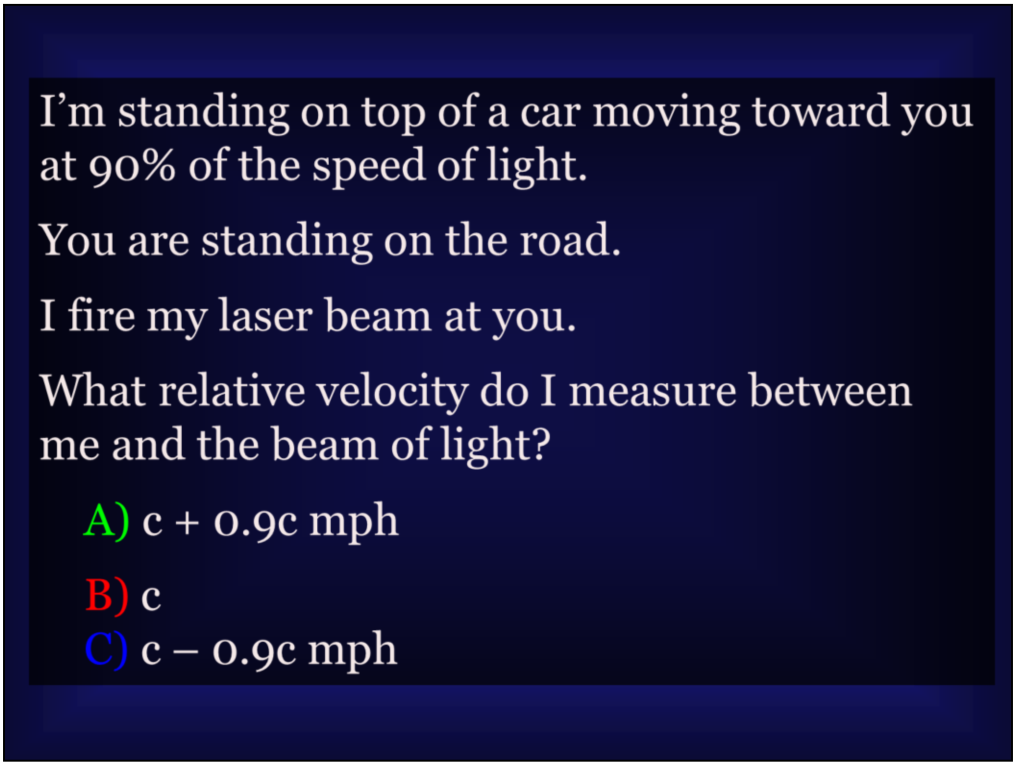
You are standing on the road.

I fire my laser beam at you.

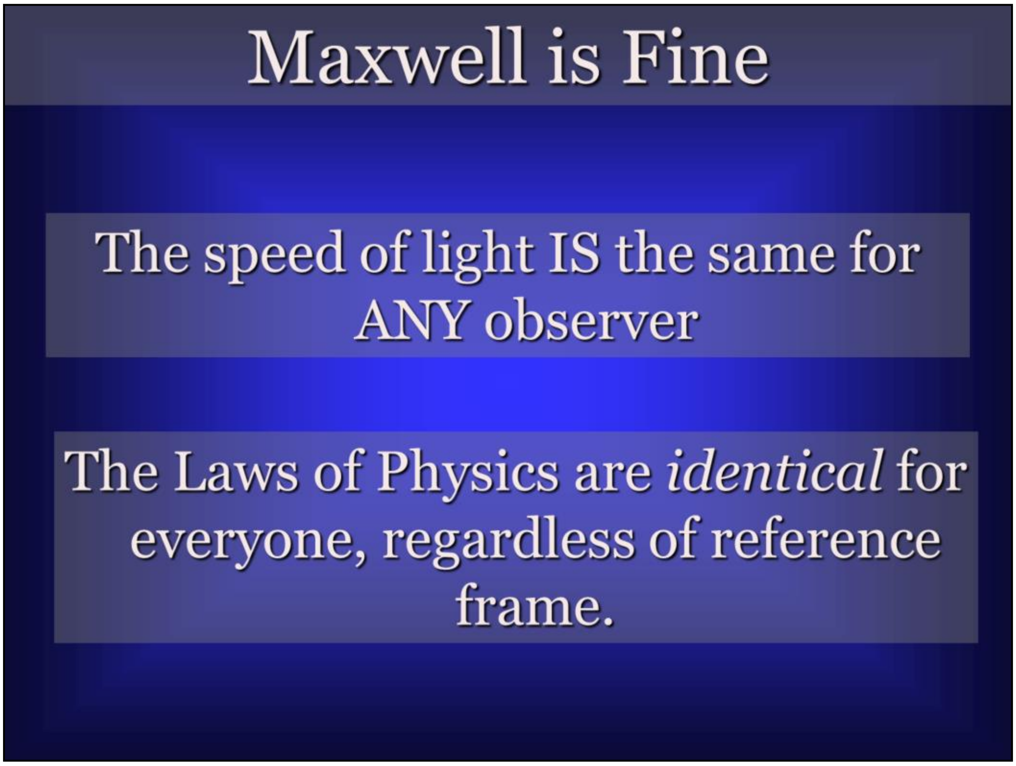
What relative velocity do YOU measure between me and the beam of light?

- A) c + 0.9c mph
- B) c
- C) c – 0.9c mph

Answer is choice C) c-0.9c



Answer is choice B) c

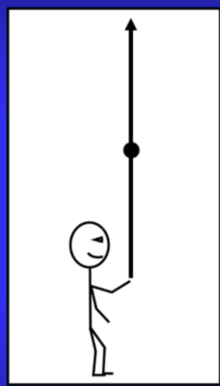


Einstein said:

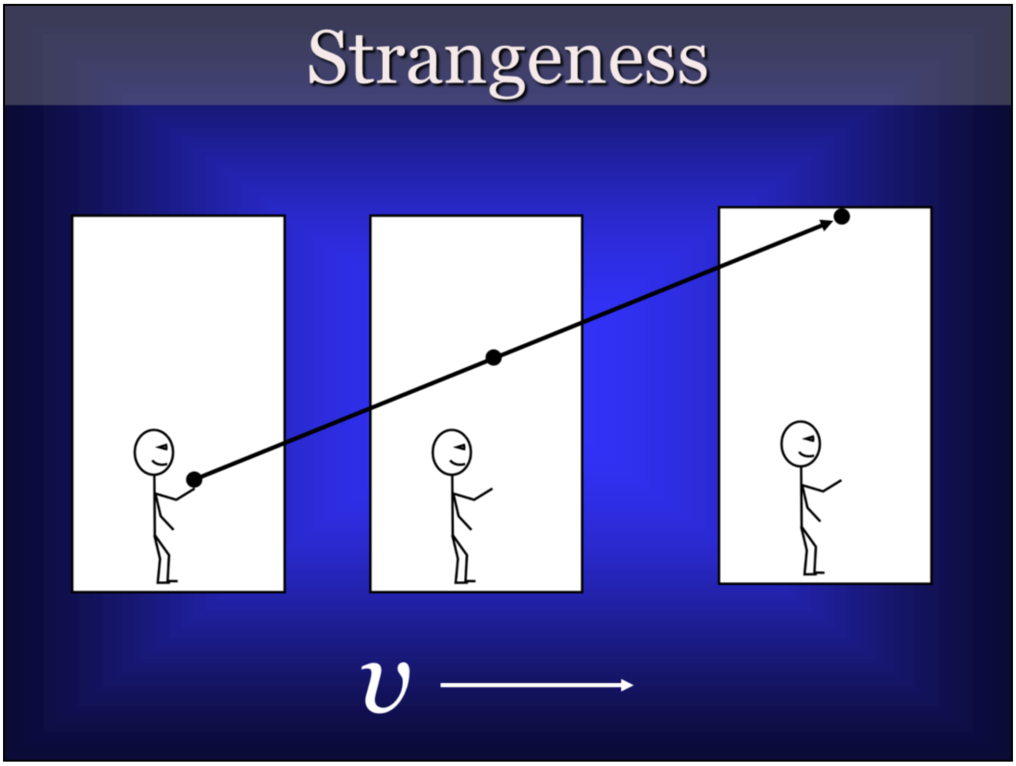
Let’s assume that everything is fine with Maxwell and that these two statements on the slide are true.

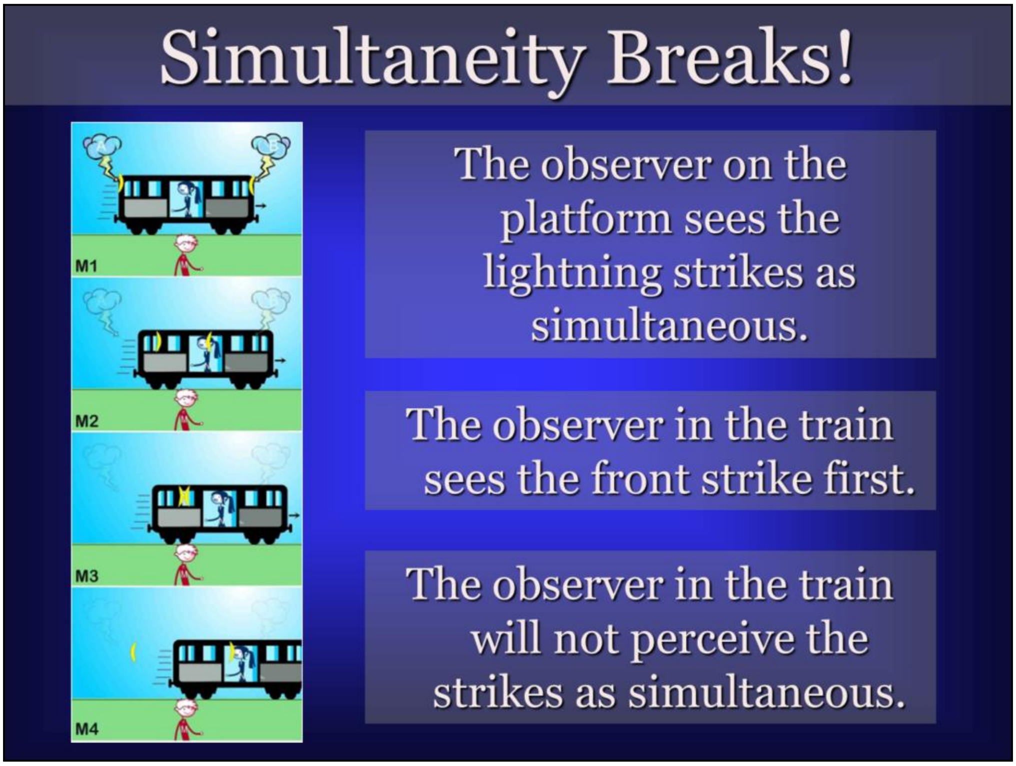
What are the consequences?

Strangeness



$$v = 0$$


Strangeness
v



Consider a bridge with a train going over it.

The front of the train crossing the far end of the bridge triggers the right light.

The rear of the train crossing the near end of the bridge triggers the left light.

If the train is the same length as the bridge, the lights flash simultaneously.

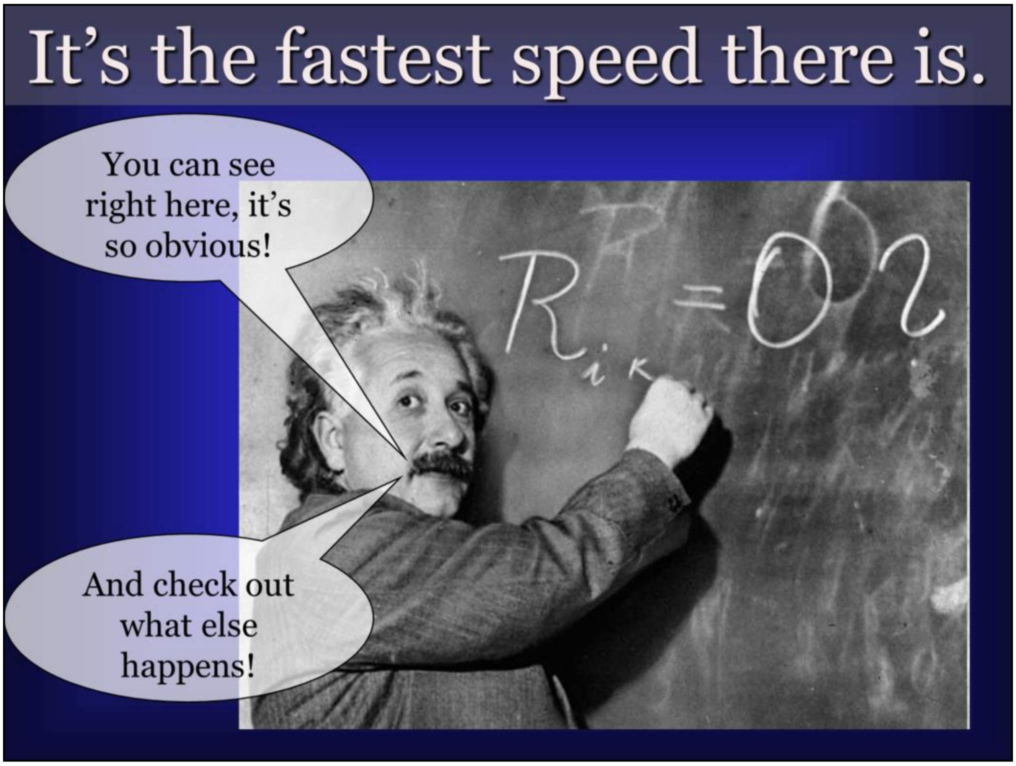
If the train is the shorter, the left flashes first.

If the train is longer, the right flashes first.

If, on the bank, I see both lights flash simultaneously, I will assume train and bridge are equal length.

The rider on the train, however, assuming that the speed of light is invariant, will disagree that the flashes are simultaneous.

The rider will see the right light flash first and determine that the train is longer.



Einstein figured out that NOTHING can go faster than light.

But it's because light is weird, and because it's weird, strange things happen when you go REALLY fast.

Science

New theory explains that the old theory is a special case

Newton is correct at speeds much less than the speed of light