Special Relativity

Newtonian addition of velocities

baseball hit from moving train at velocity v (40 mph)

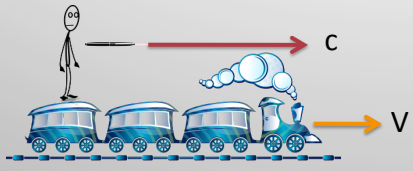
train velocity V (60 mph)

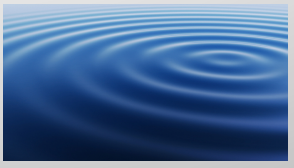
What velocity do we measure for baseball?

v + V = 40 mph + 60 mph = 100 mph

…"common sense"

Two (wrong) intuitive views of light





We see light move at speed (c+V)

i.e. depends on speed of emitter of light

Light moves at speed c with respect to some medium (the "aether")

…what we see depends on our motion through aether

Experimentally

Speed of light is measured to be the same by *all* observers

Michelson-Morley experiment (1887) failed to detect effect of Earth moving through aether on speed of light…

Experimentally

Speed of light is measured to be the same by *all* observers

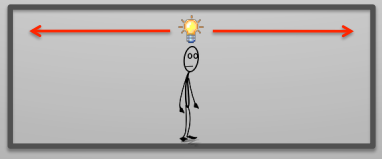
No deeper reason for "why" this is so…
an observed fact of nature

Einstein

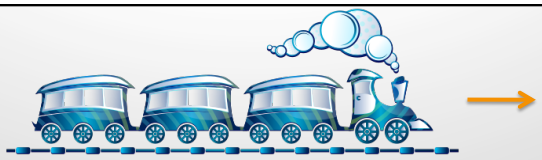
Elevated this fact to the status of a central postulate of Special Relativity

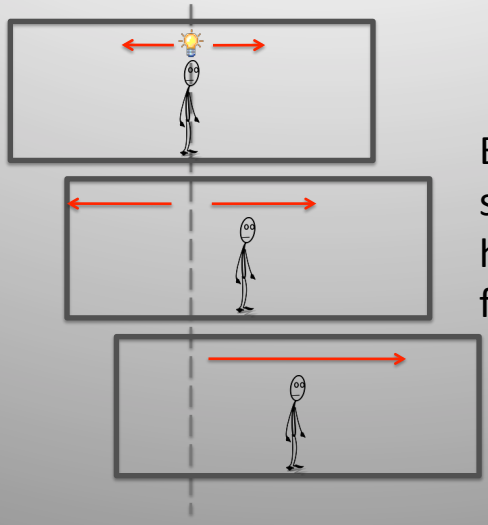
- The laws of physics don't depend on your state of motion
- The speed of light in vacuum is c for all observers

Relativity of simultaneity



observer *in* train, light pulse hits front and back of car at same time





External observer sees light pulse hit back wall first

…who shoots first?

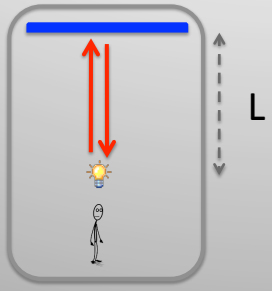
Relativity of simultaneity

When is simultaneity *not* relative…

Events that occur simultaneously *at the same place* for one observer are simultaneous for everyone

…no disagreements about causality!

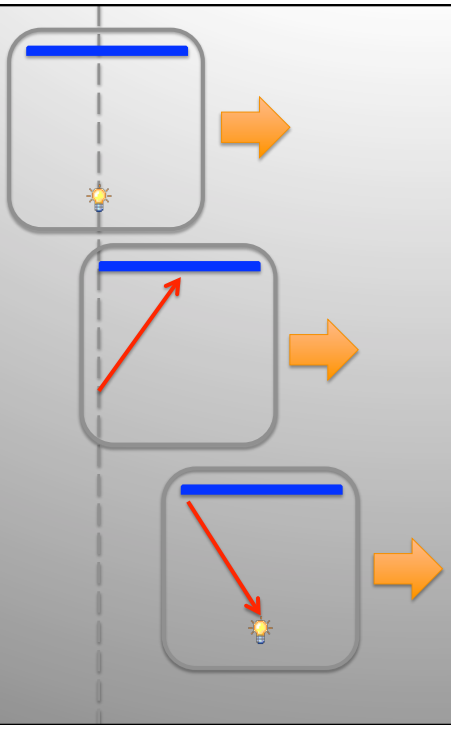
Time dilation



Build a clock with light: one "tick" is time for light to hit mirror and bounce back

Time this takes is:

$$t = \frac{2L}{c}$$

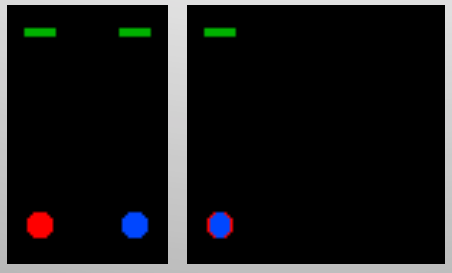


When the clock is moving…

Light has further to go: since *speed* is the same, must take longer

Moving clocks run slow

When the clock is moving…



Animated version courtesy Andrew Hamilton

Easy to visualize with light, but nothing special about this type of clock…