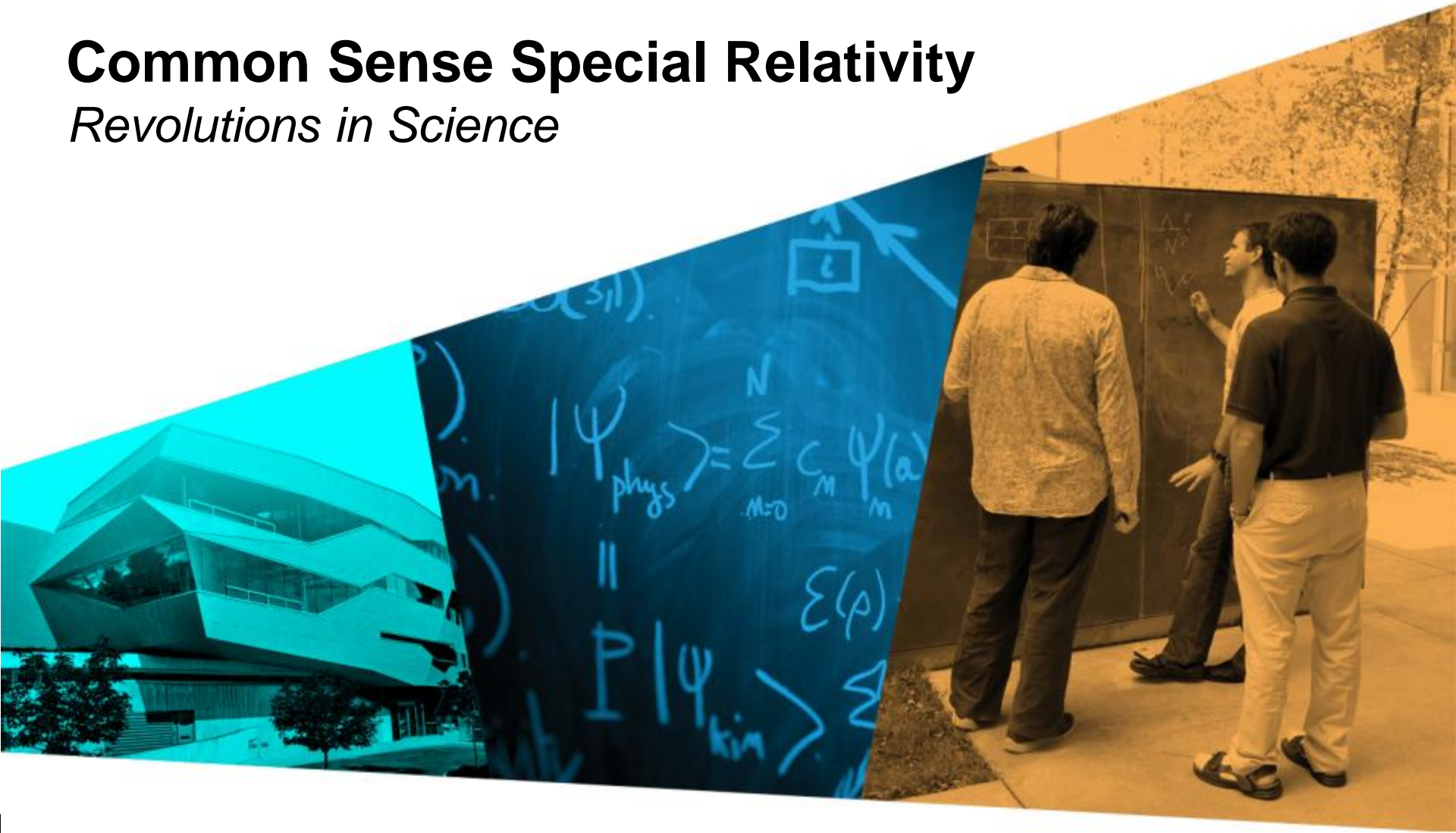
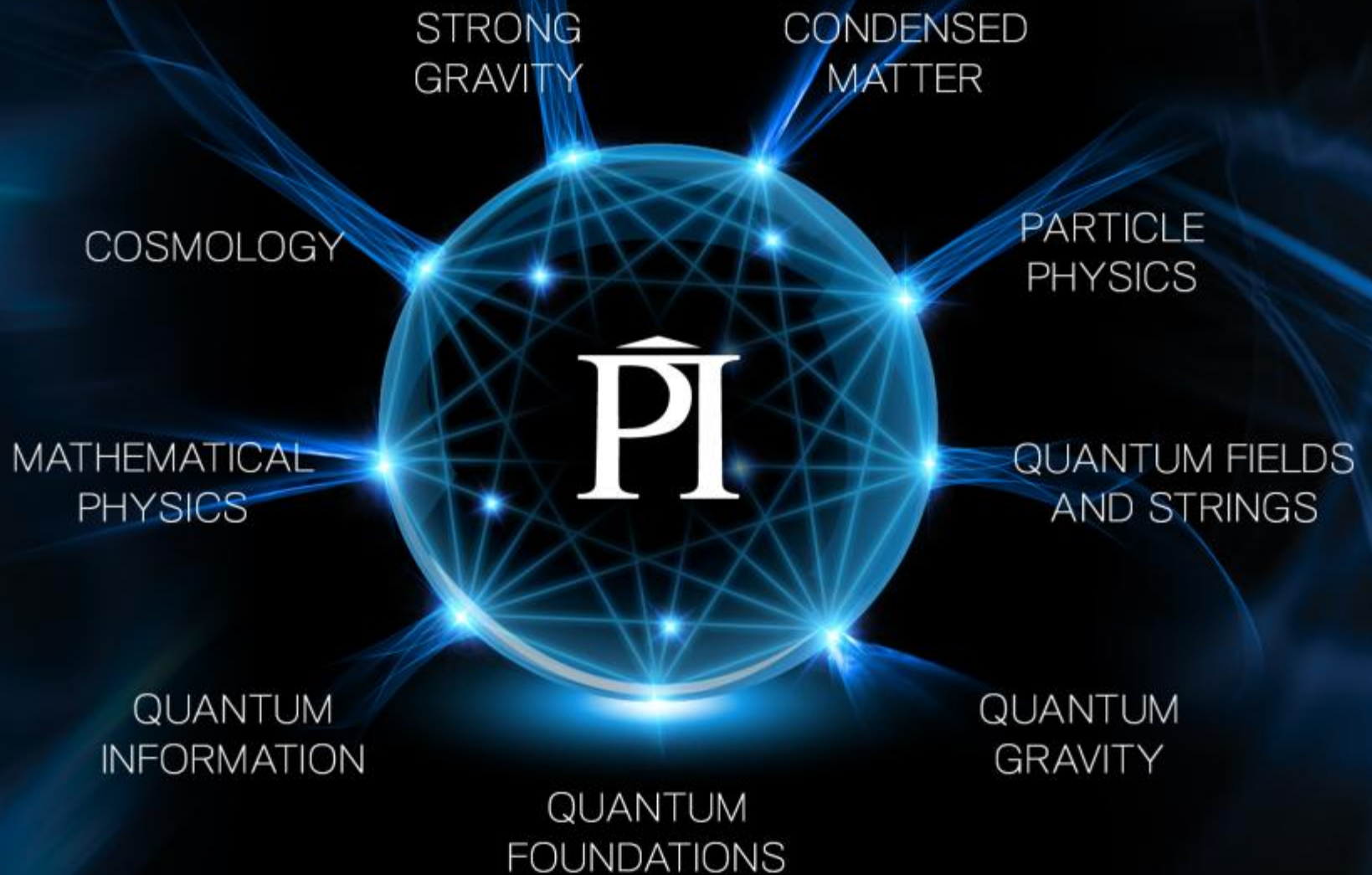


# Common Sense Special Relativity

*Revolutions in Science*







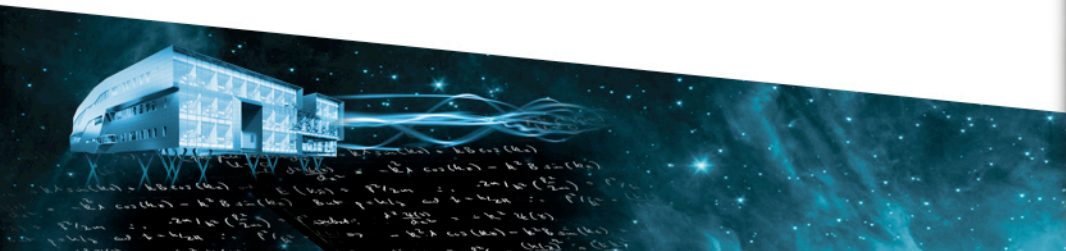


# Inspirational Programs

## Einstein Plus

Physics summer camp for high school teachers from around the globe.

- Physics workshops and discussions
- Keynote talks, researcher interaction
- IQC tour
- Social Interaction





# Classroom Resources

Teacher-Researcher  
Collaboration

Professional Production



# Current Titles

Beyond Particle Physics: Remodelling the Atom  
 The Challenge of Quantum Reality  
 The Mystery of Dark Matter

Process of Science

Revolutions in Science

GPS and Relativity

Planck's Constant





# ***Revolutions in Science***

- 9 one minute animations
- 6 student activities
- Supplementary  
Information

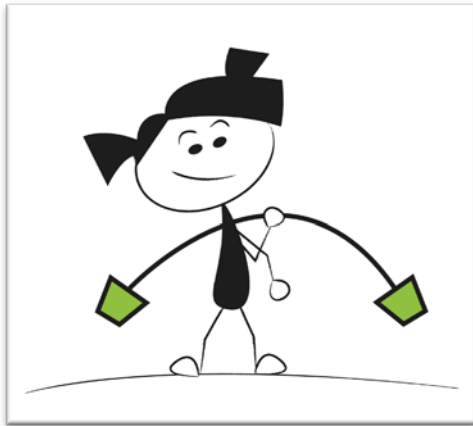




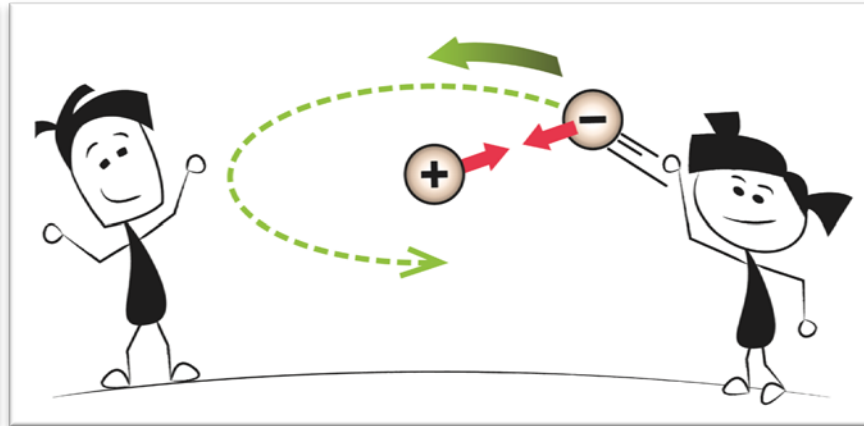


# ***Revolutions in Science***

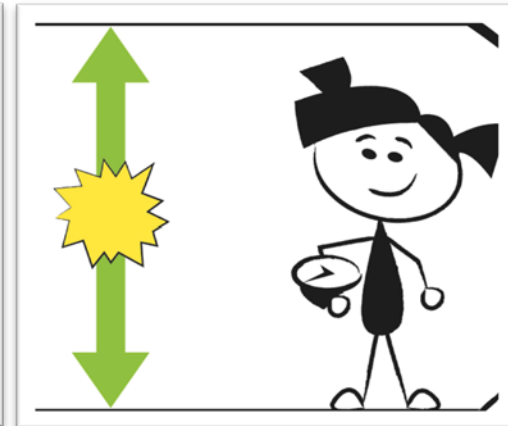
Students engage with three powerful **ideas**:



Gravity



The atom



Time



# Where does energy come from?

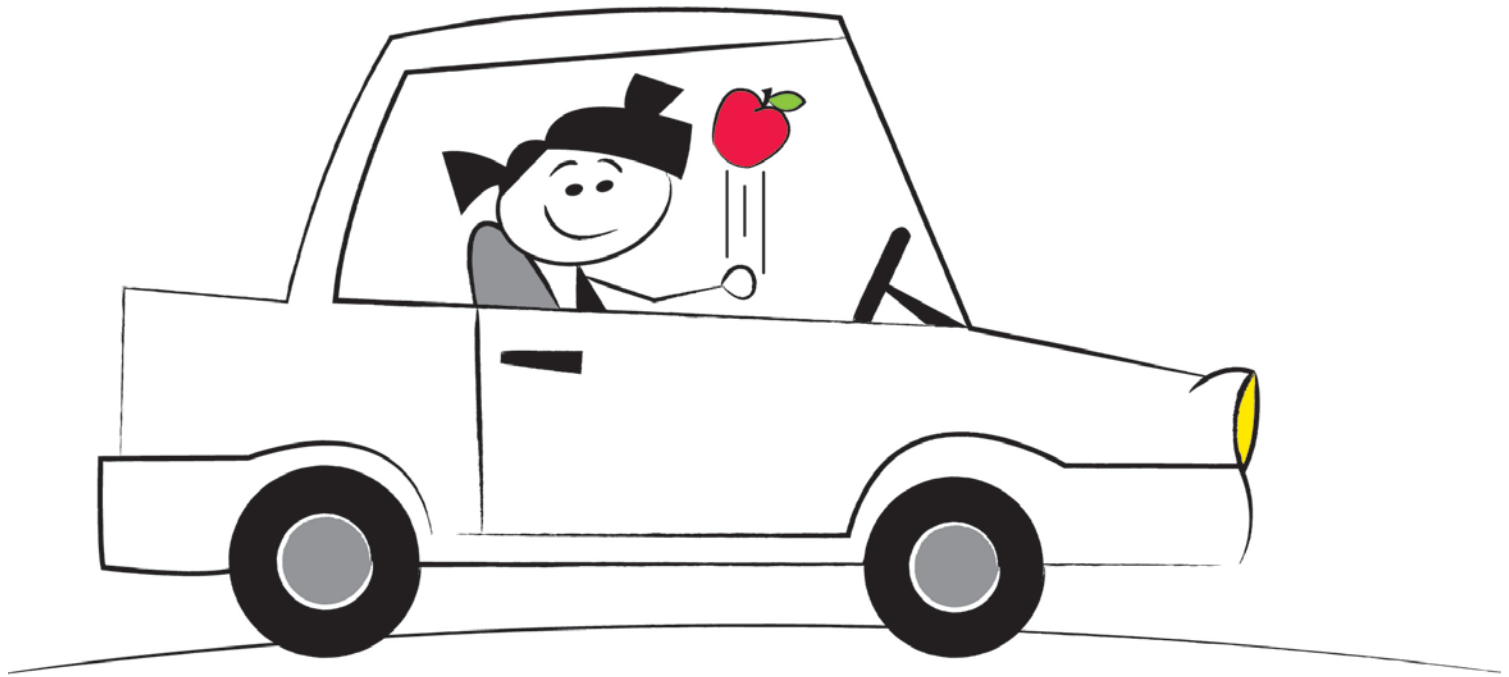




# Galilean Relativity

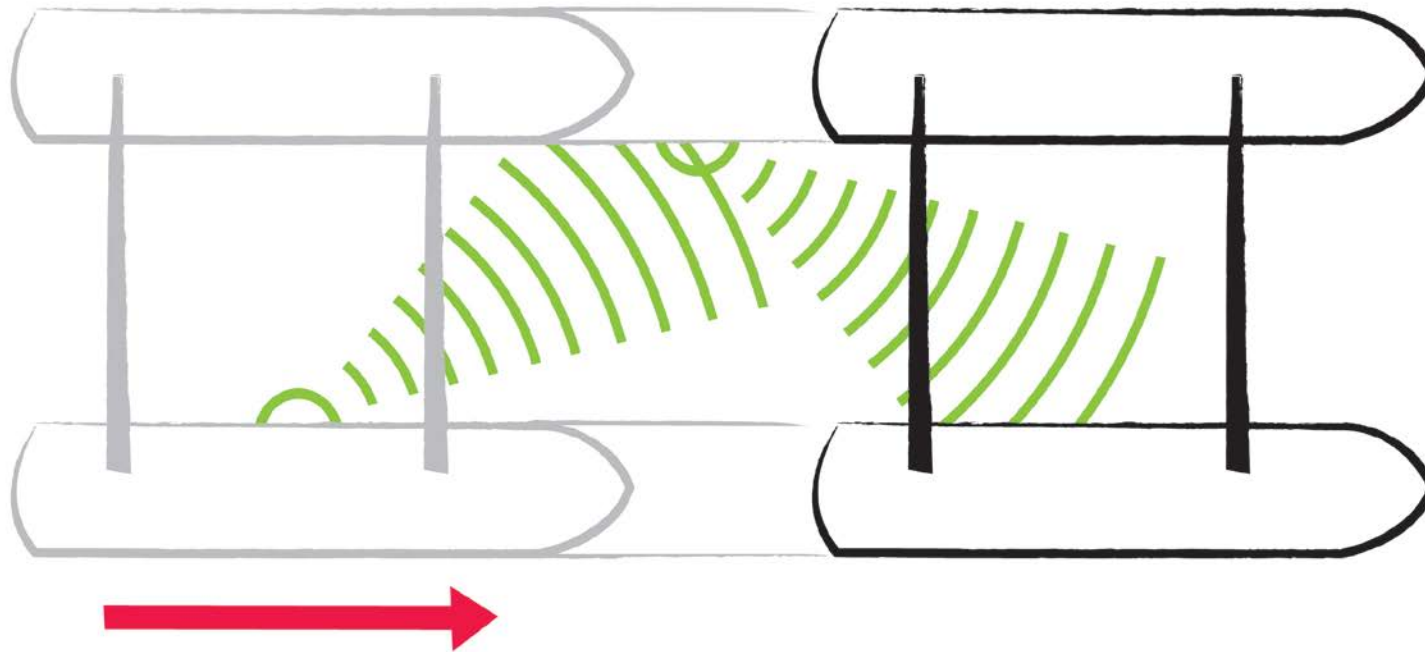


# Can you tell you are moving?

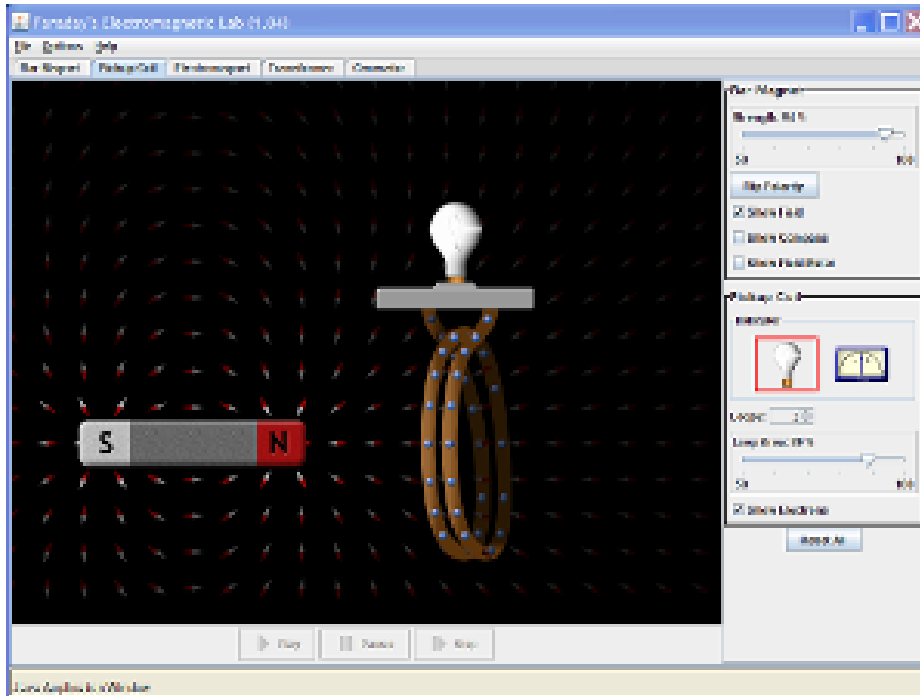




# Can you tell you are moving?



# Einstein's Problem



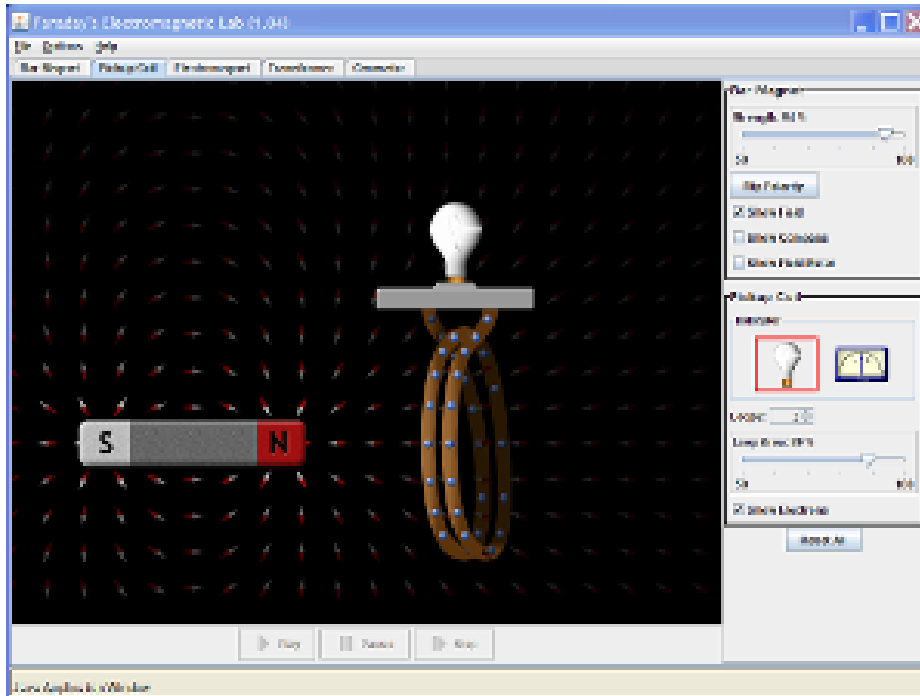
A moving magnet creates an electric current in the coil.

HOW?





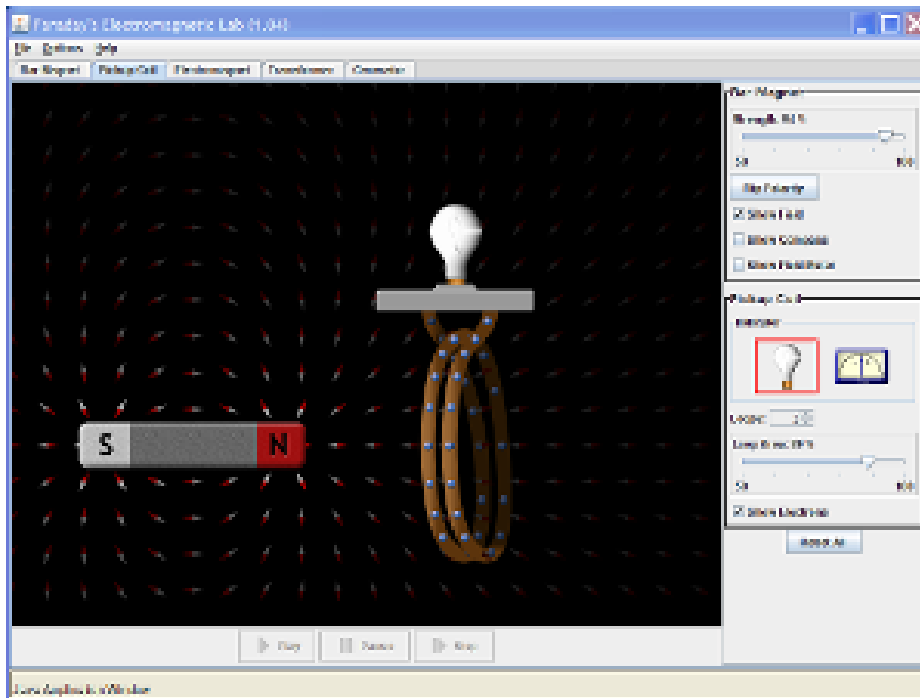
# Einstein's Problem



Moving magnet  
creates an electric  
field that  
produces a  
current in the coil.



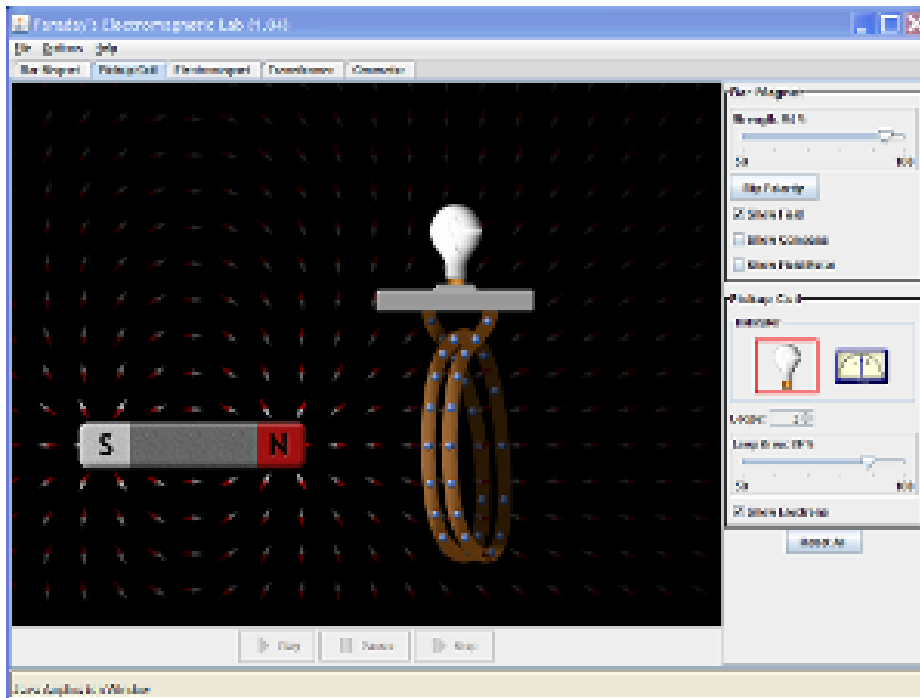
# Einstein's Problem



What if we move  
the coil instead of  
the magnet??



# Einstein's Problem



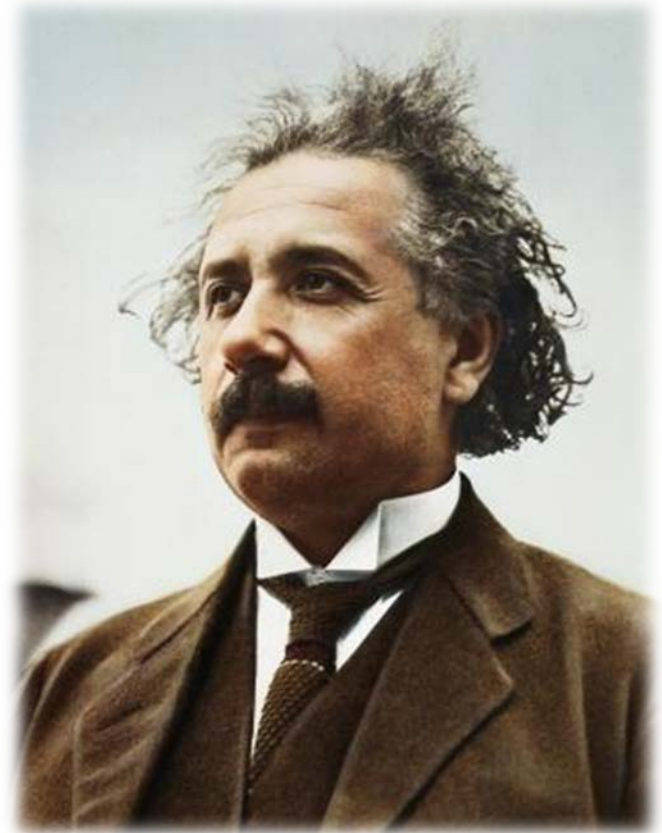
Magnetic field  
exerts a force on  
electrons to  
produce the  
current in the coil.



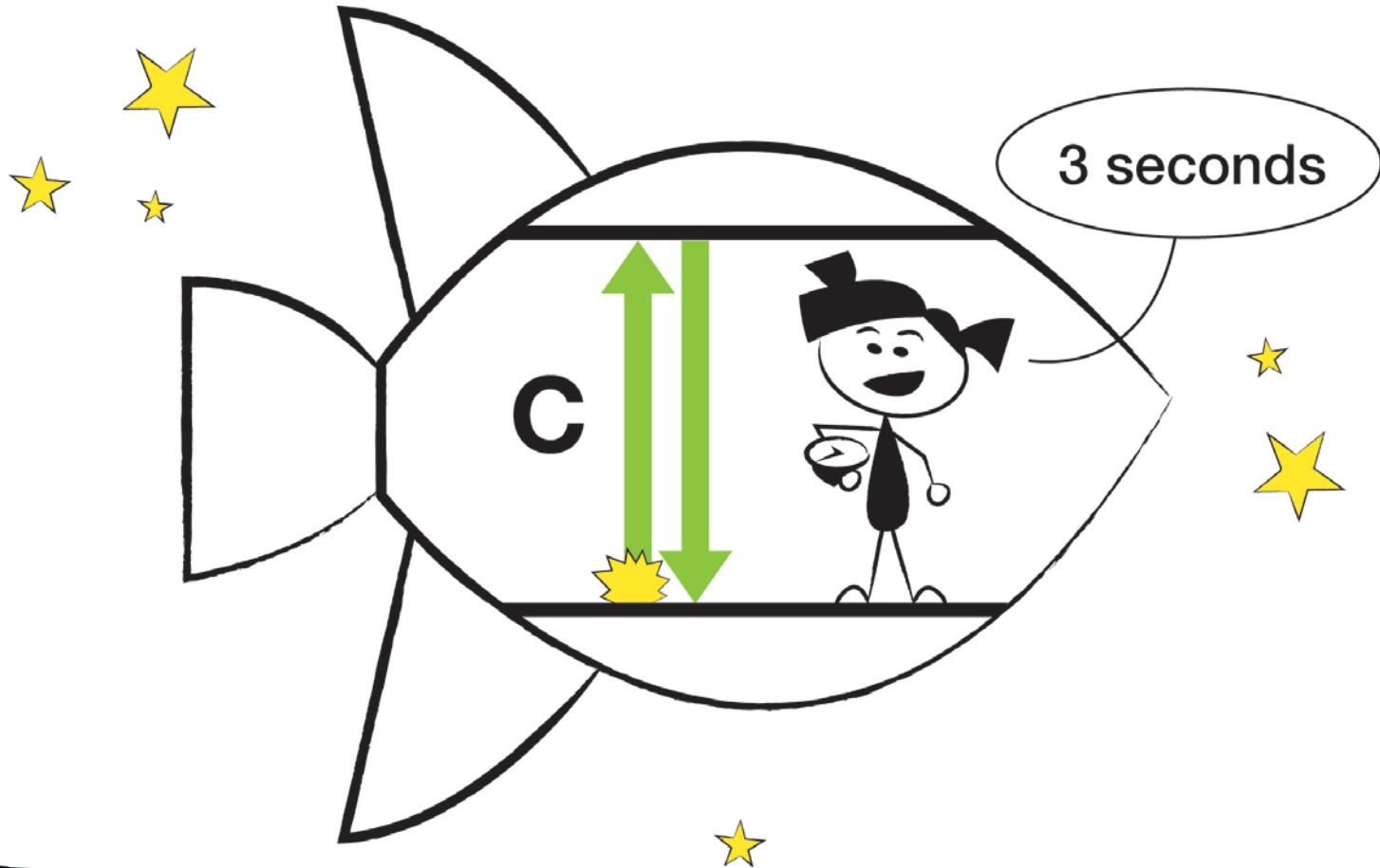


# Einstein's Problem

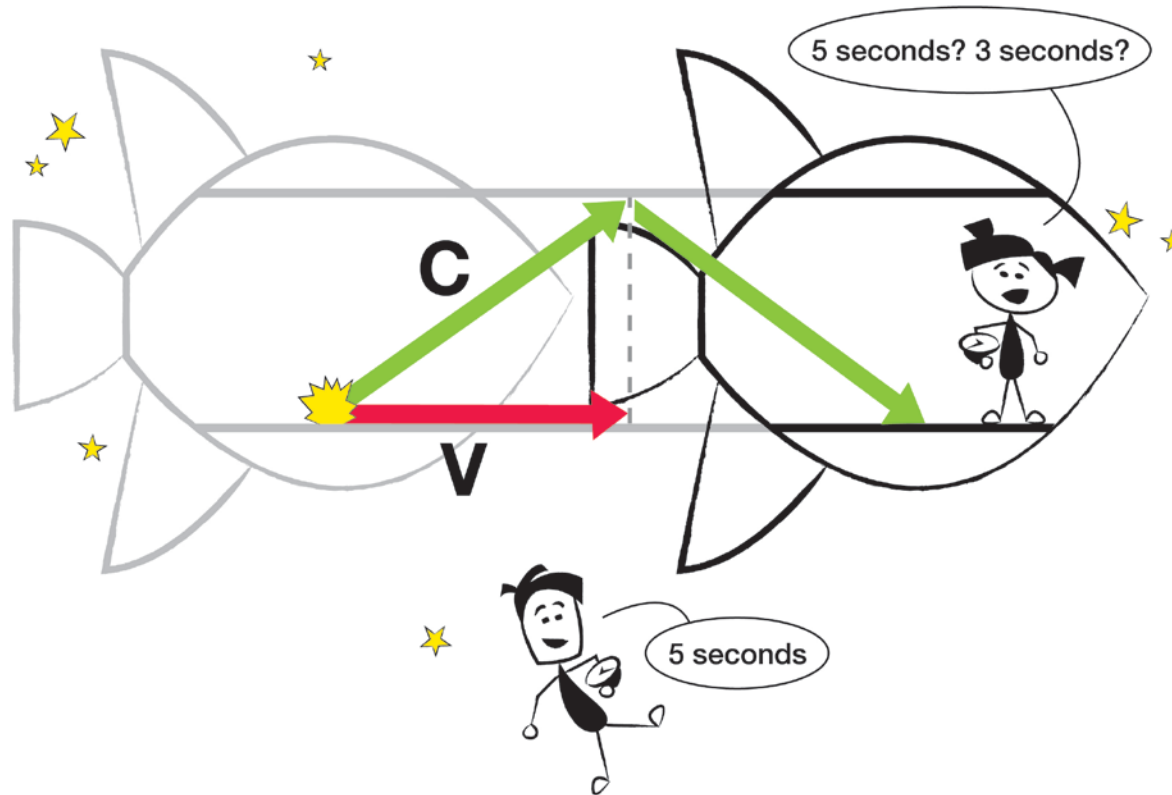
Why should a change  
in frame of reference  
result in different  
explanations for  
induced current?



# Can you tell you are moving?



# Will Bob and Alice agree?





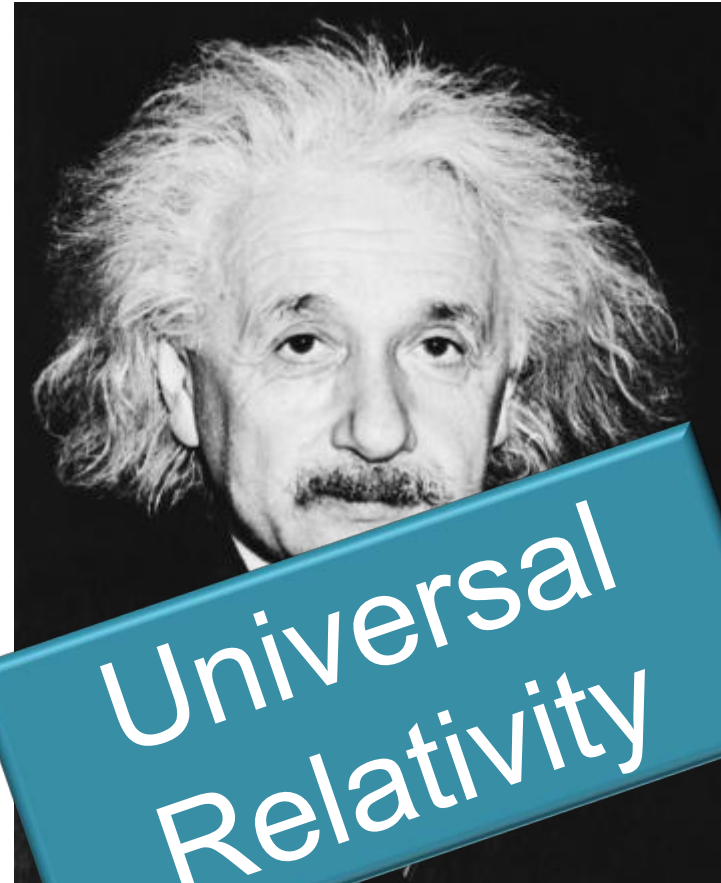
**Newton**

**vs**

**Einstein**



**Absolute  
Time**



**Universal  
Relativity**



# Something to consider...

The speed of a  
wave NEVER  
depends on the  
speed of the  
source.



Something to consider...

*Special Relativity*  
*does NOT*  
*eliminate the ether.*





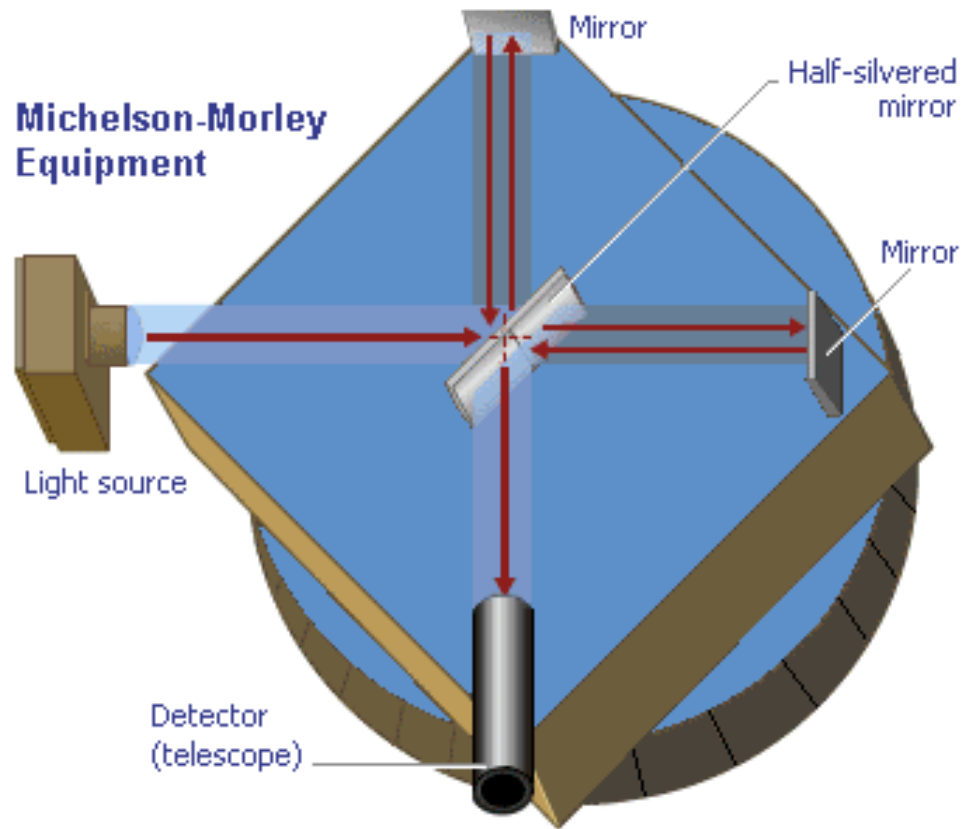
# Something to consider...

*More careful reflection teaches us, however, that the special theory of relativity does not compel us to deny ether.*

– Albert Einstein



# Something to consider...



*Michelson-Morley  
only eliminates  
the ether in a  
Newtonian  
space-time*



# Something to consider...

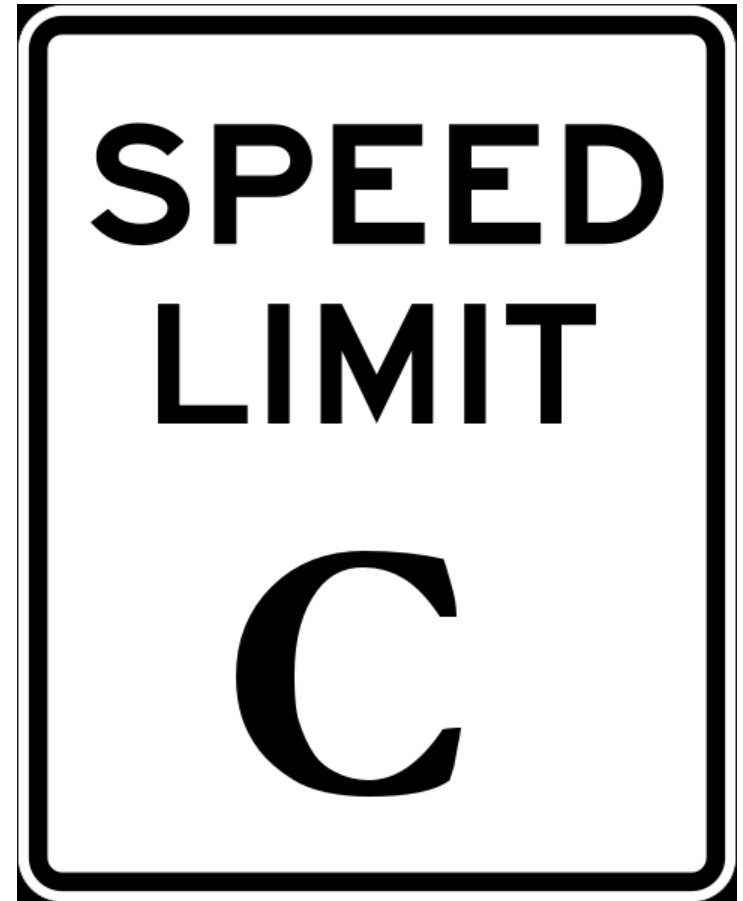
Time Dilation and  
Length Contraction  
are *logical*  
*consequences* of  
Universal Relativity.





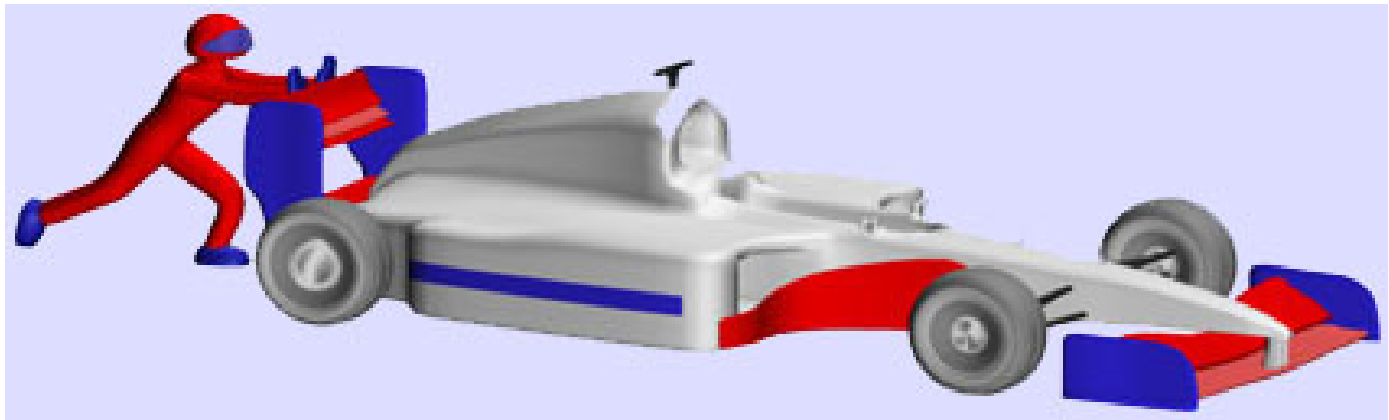
# Something to consider...

The speed limit is a  
*logical*  
*consequence* of  
time dilation and  
length contraction.



# Something to consider...

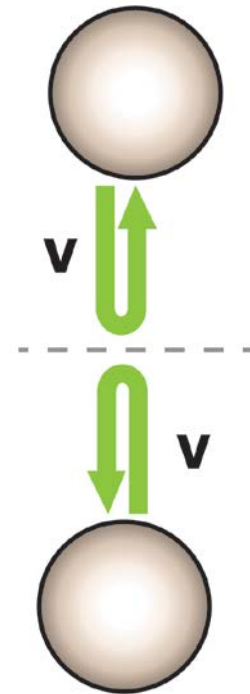
Mass NEVER increases. Time dilation and length contraction just make the applied force less effective.



# Consider the collision of two Super Balls

Each has speed  $v$  going in and out of collision.

How do their masses compare?





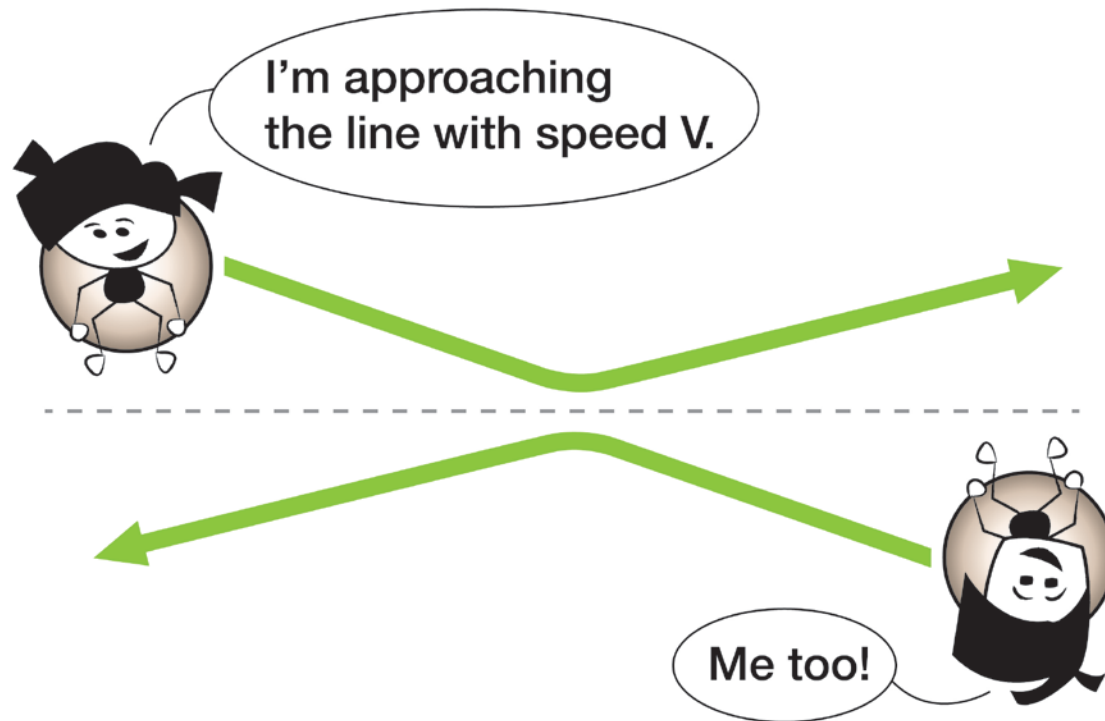
# Consider the collision of two Super Balls

One has speed  $v$  going in and out, the other has a greater speed  $V$  going in and out of the collision.

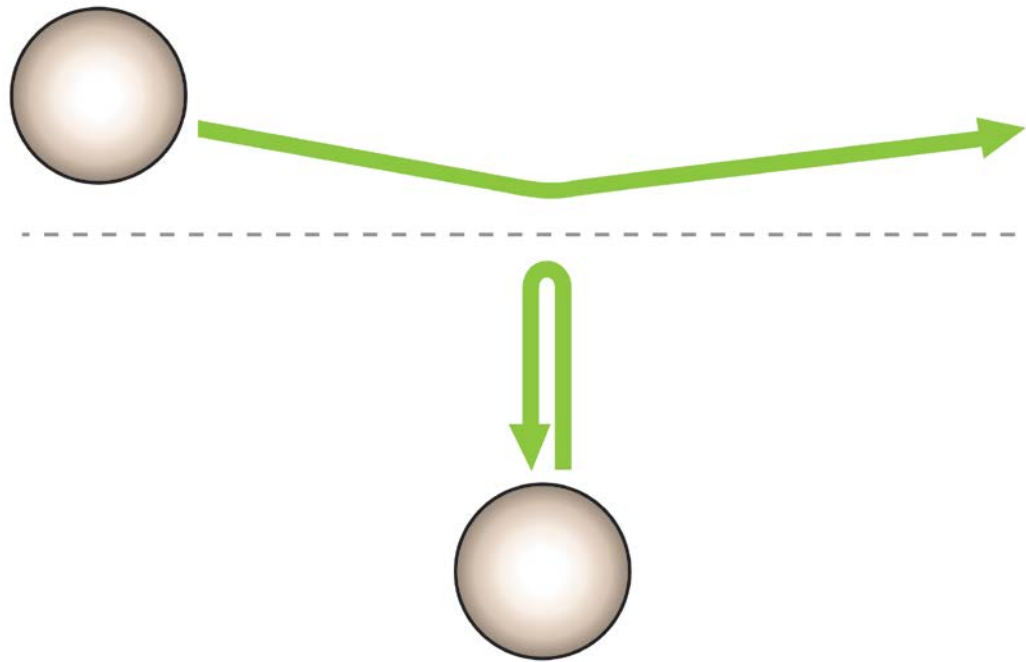
How do their masses compare?



# Now consider a glancing collision...

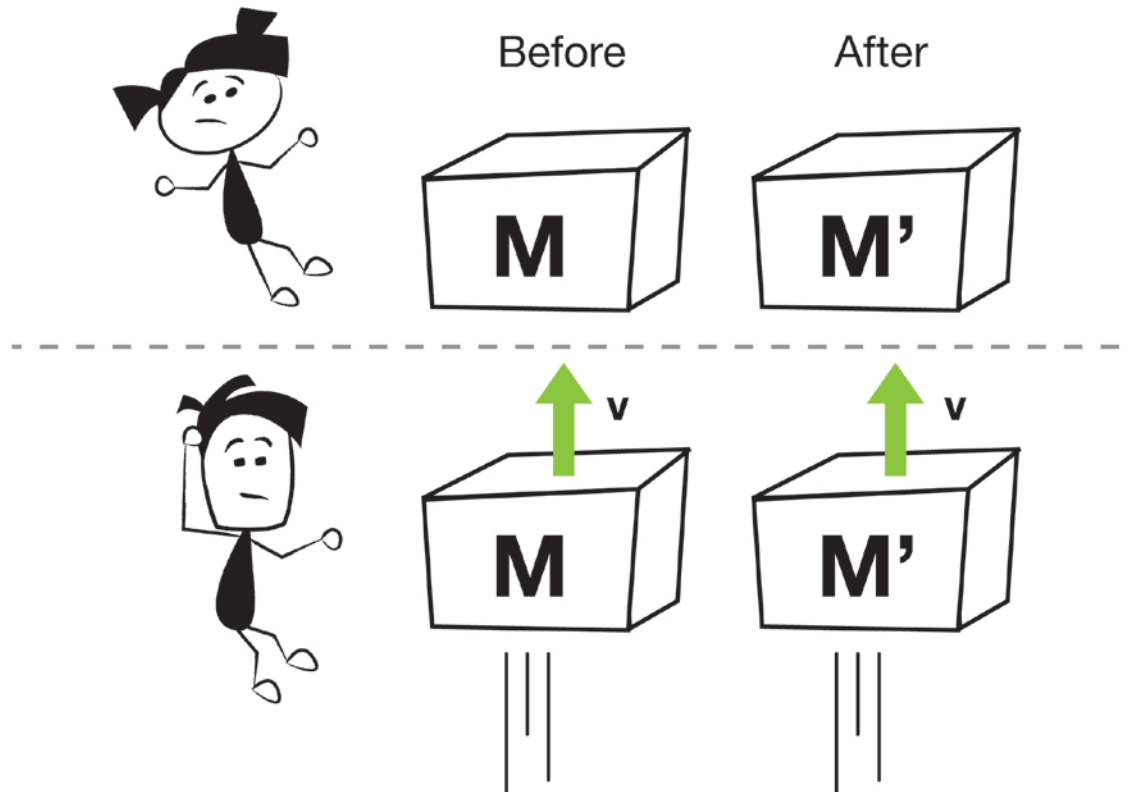


# Running parallel to Bob...

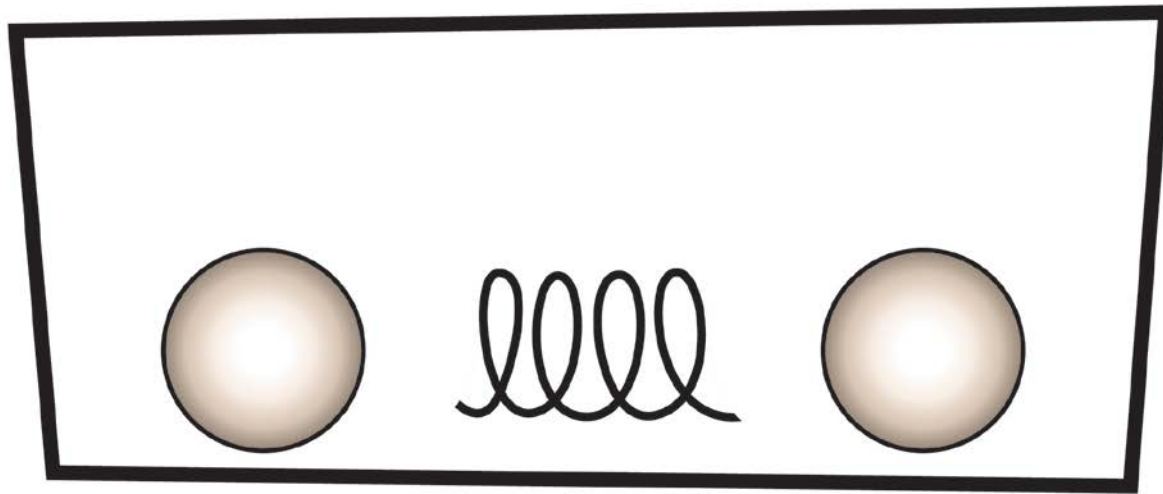




# Can the mass of a box suddenly change?



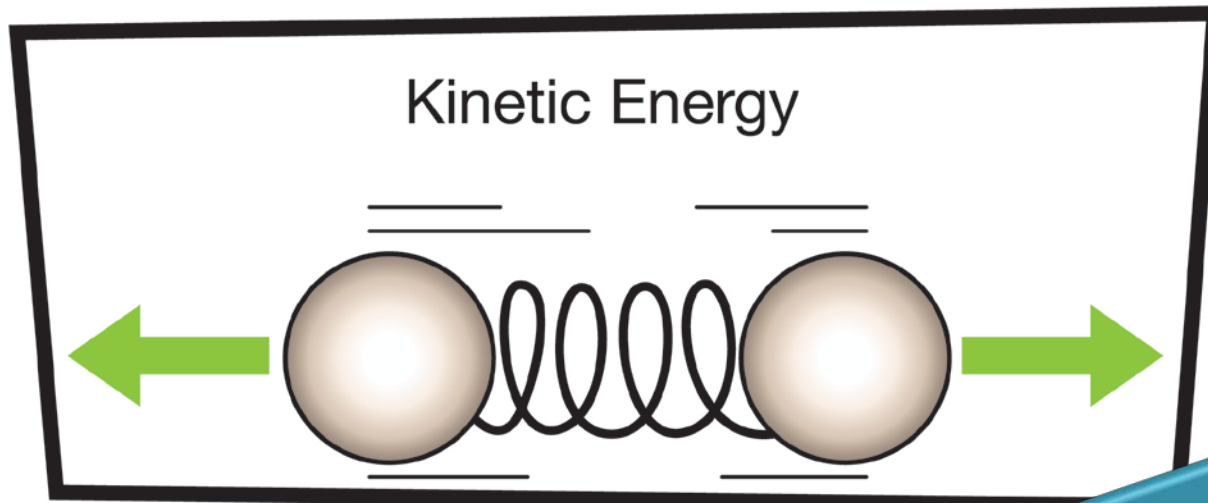
**Open the box to find two heavy spheres  
and a very special spring...**



**Assemble, put in motion, close box...**



# Vibrates at high speed...



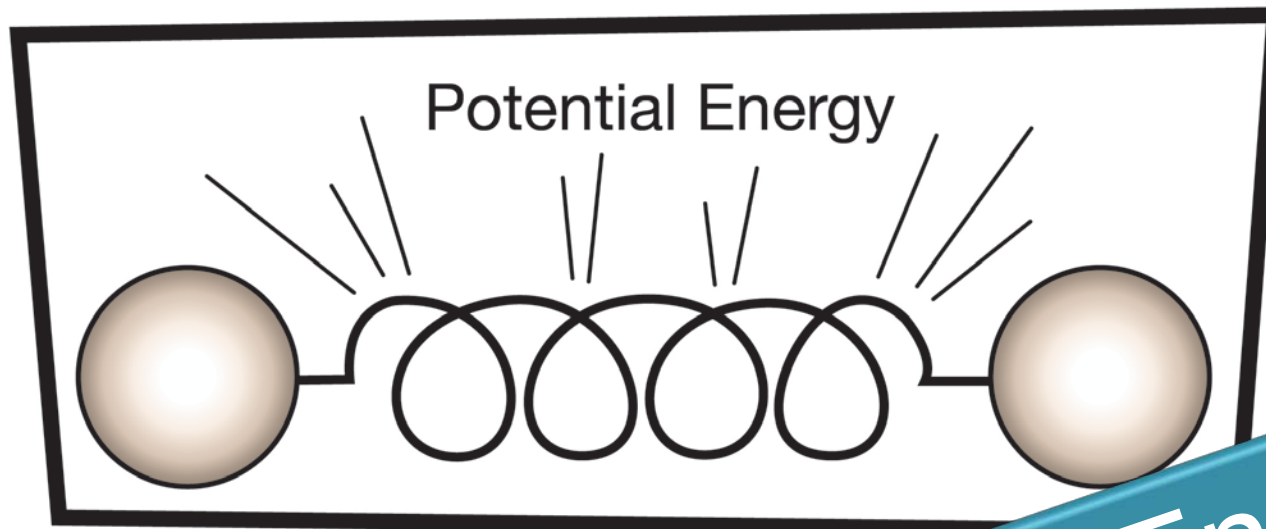
What happens to the

**Kinetic Energy  
has Inertia**





# When the spring is fully stretched...

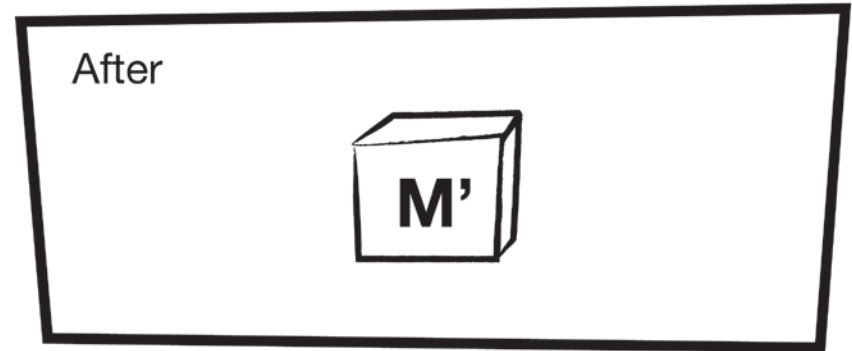
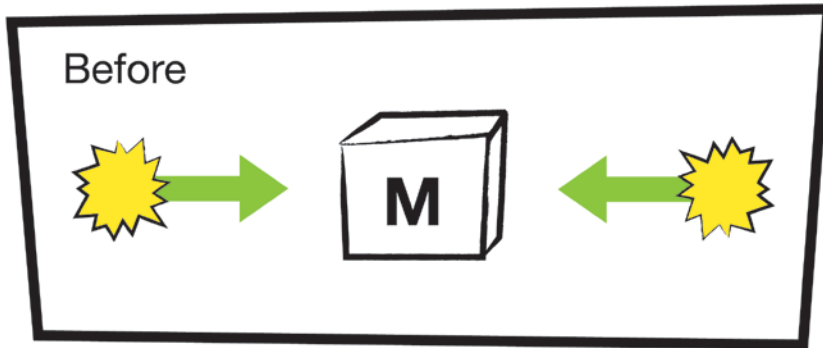


What happens to the

Potential Energy  
has Inertia



# Shine light on a brick.



What happens to the mass of the brick?

**Light Energy  
has Inertia**

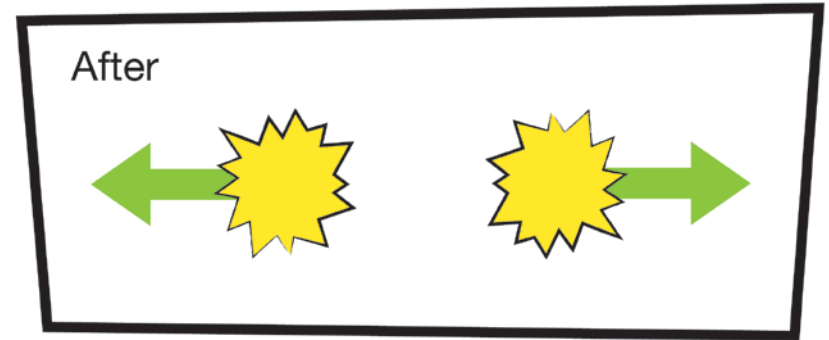
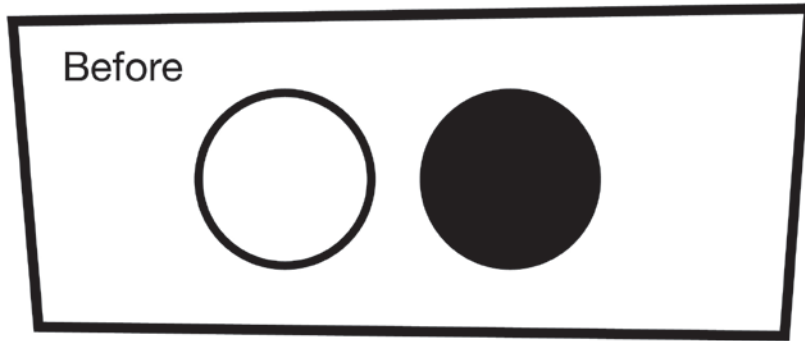


# ENERGY has INERTIA





# Matter and antimatter annihilate...



What happens to the mass of the box?



**Mass is a form of energy...**

$$E = mc^2$$

**This equation is a special case of a more general expression...**



# Energy-Momentum Equivalence

$$E^2 = m^2 c^4 + p^2 c^2$$

where  $p = \gamma m v$





For objects that are “at rest”,  $p=0$  and

$$E = mc^2$$



For massless objects,  $m=0$  and

$$E = pc$$

**NB: Momentum of light is a classical result from Maxwell's equations...**



**In summary, the core ideas in Relativity...**

You cannot tell that you are moving!!

Time and space are relative.

Nothing mysterious here, just simple logical consequences...





# Thank You!!

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