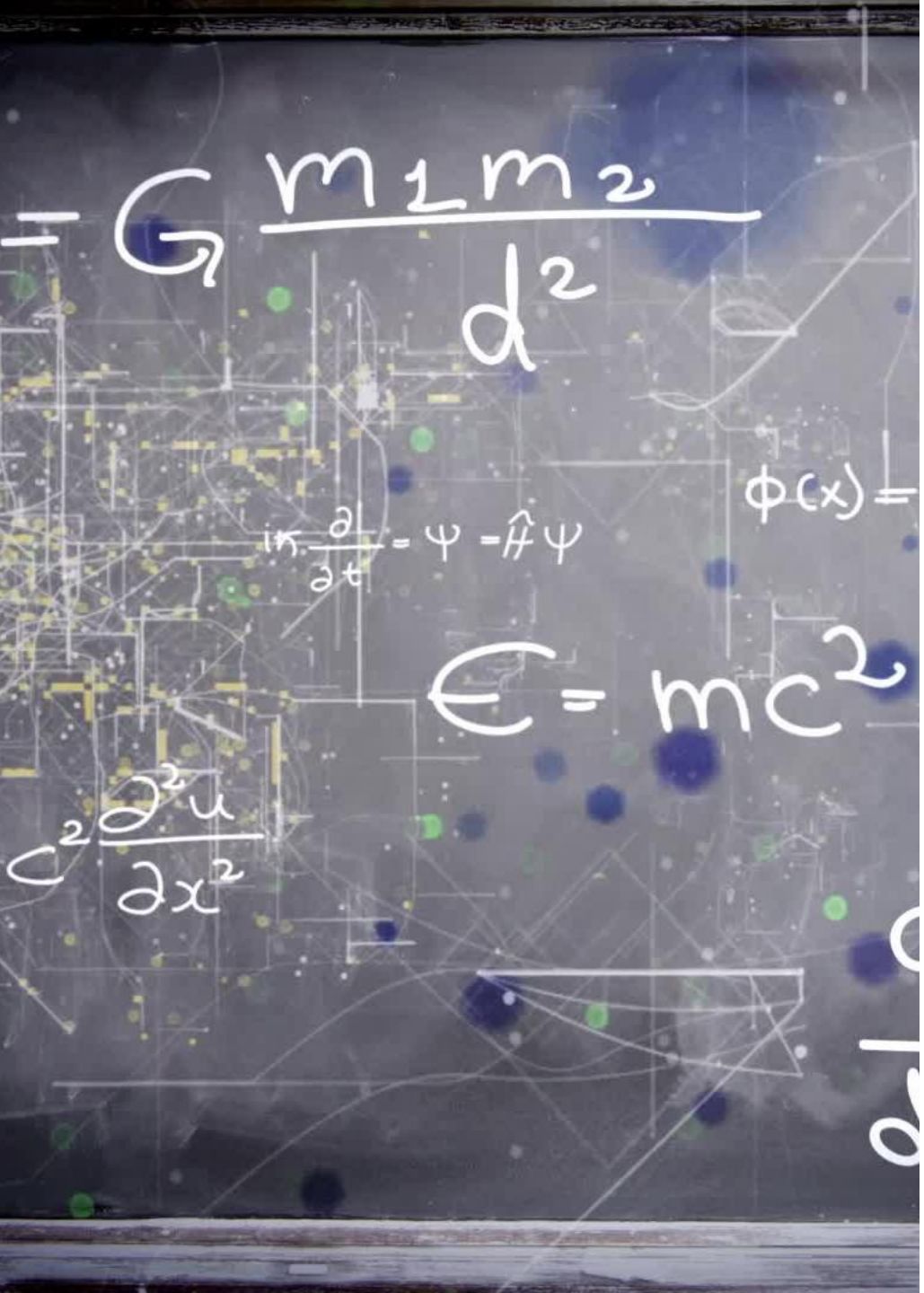
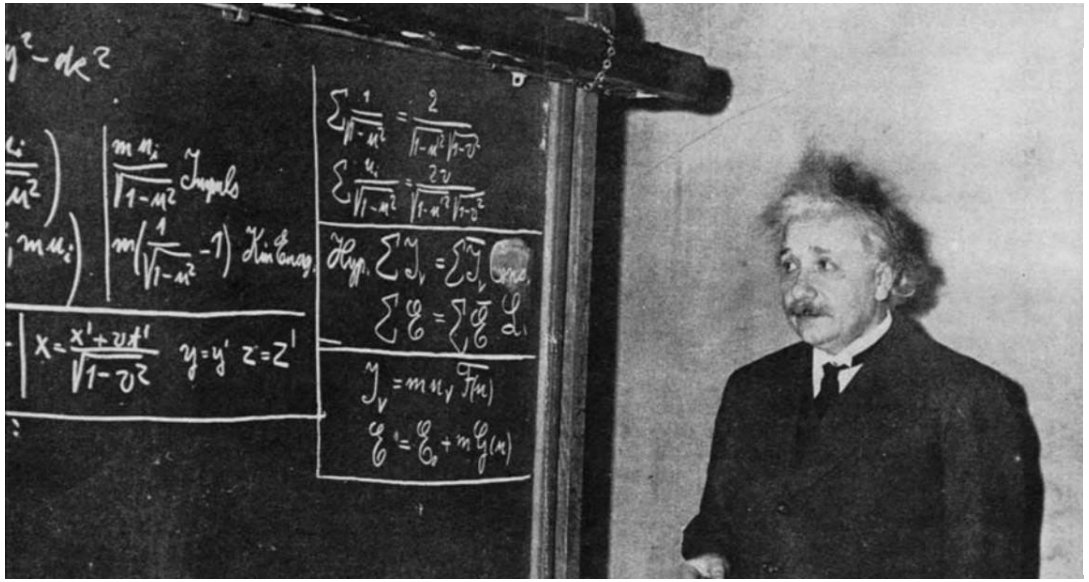


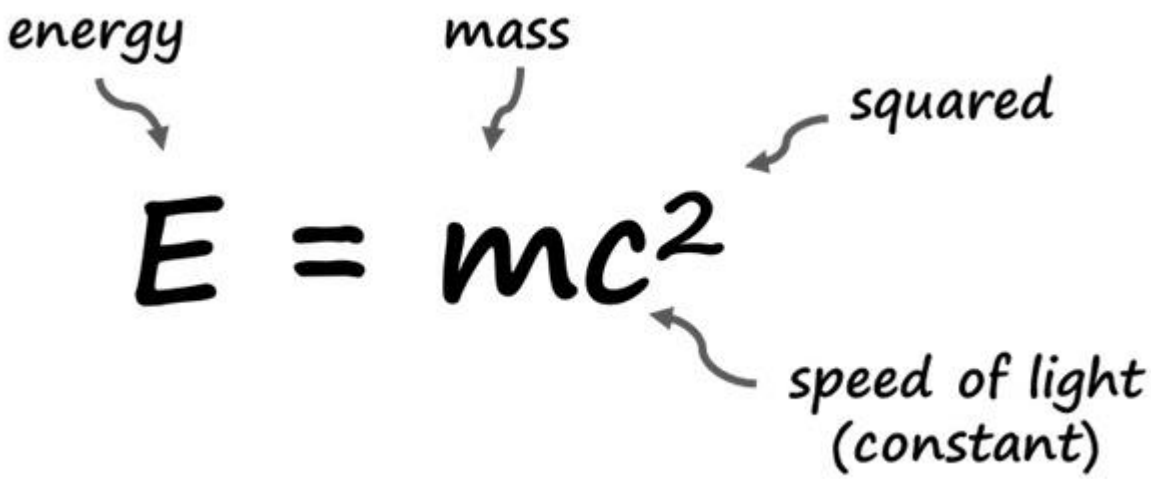
LESSON 5.1: EINSTEIN AND RELATIVITY

Physics 12 – Mr. Harris 2026

ALBERT EINSTEIN

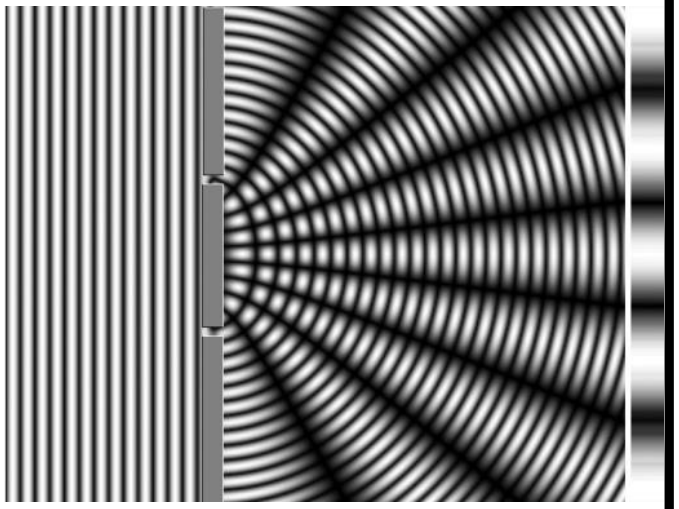
- One of the most important and creative thinkers in history
  - Proposed mass–energy equivalence ($E = mc^2$)

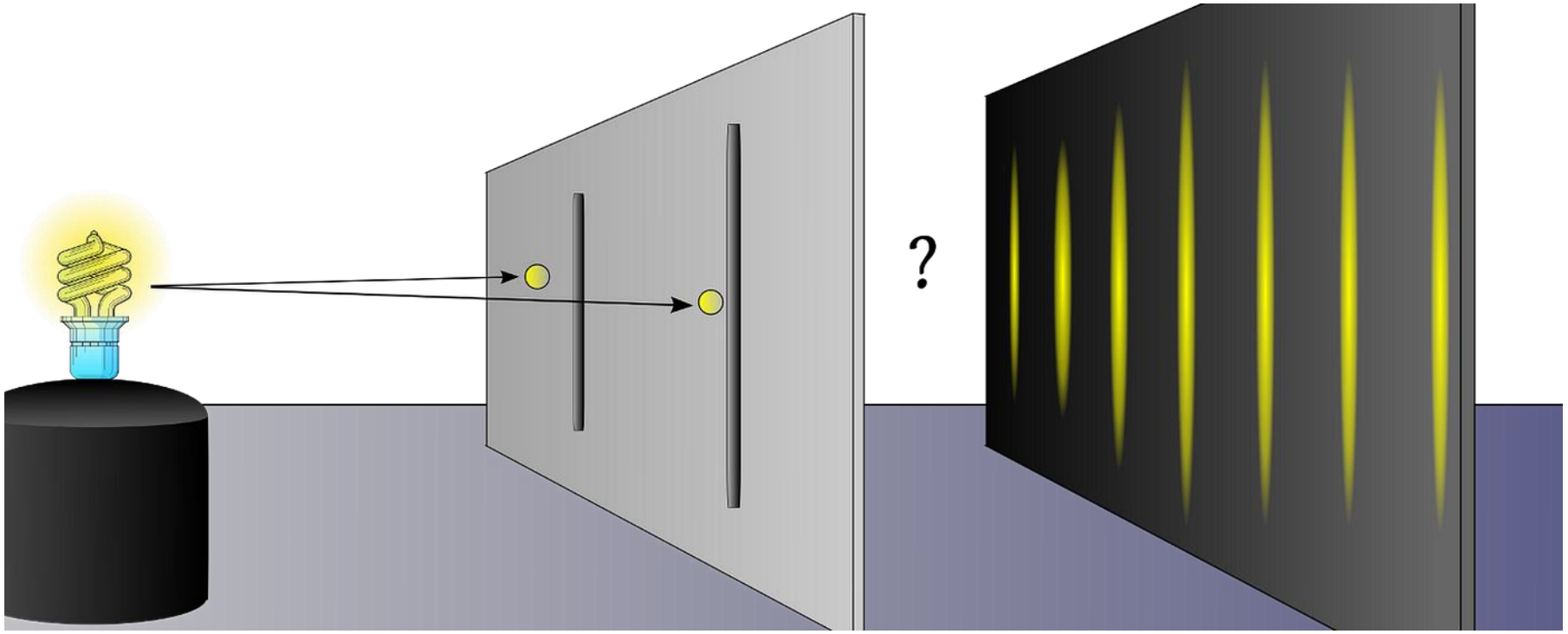




ALBERT EINSTEIN

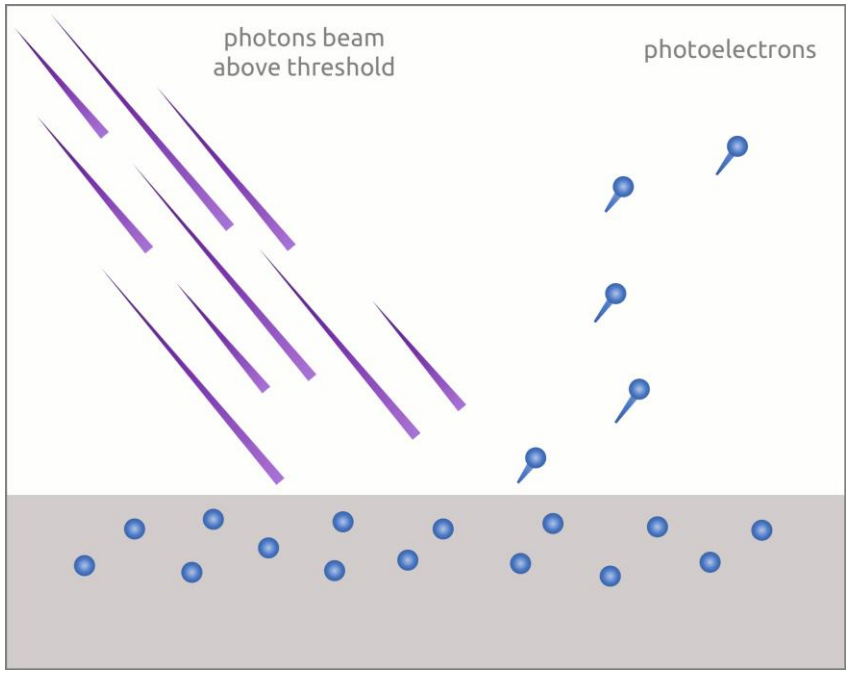
Explained light as both waves and particles (**photons**)

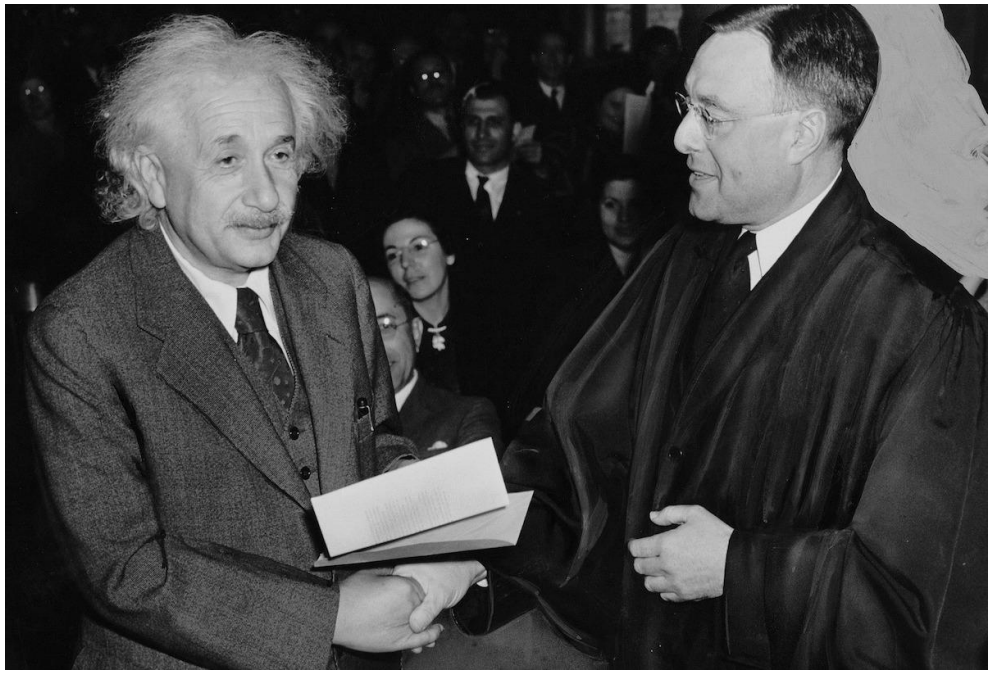




ALBERT EINSTEIN

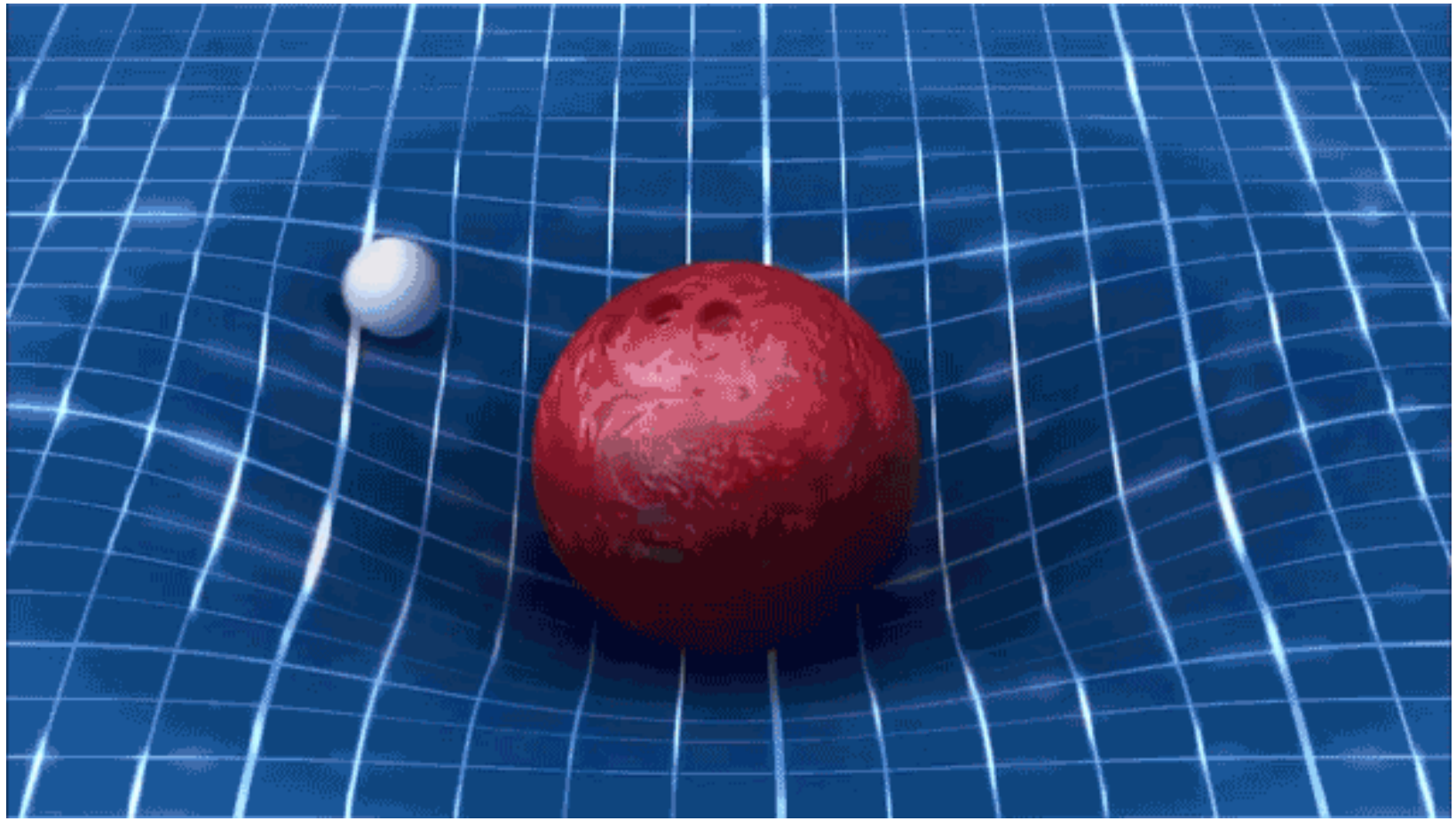
Nobel Prize in Physics for **Photoelectric** Effect (1921)



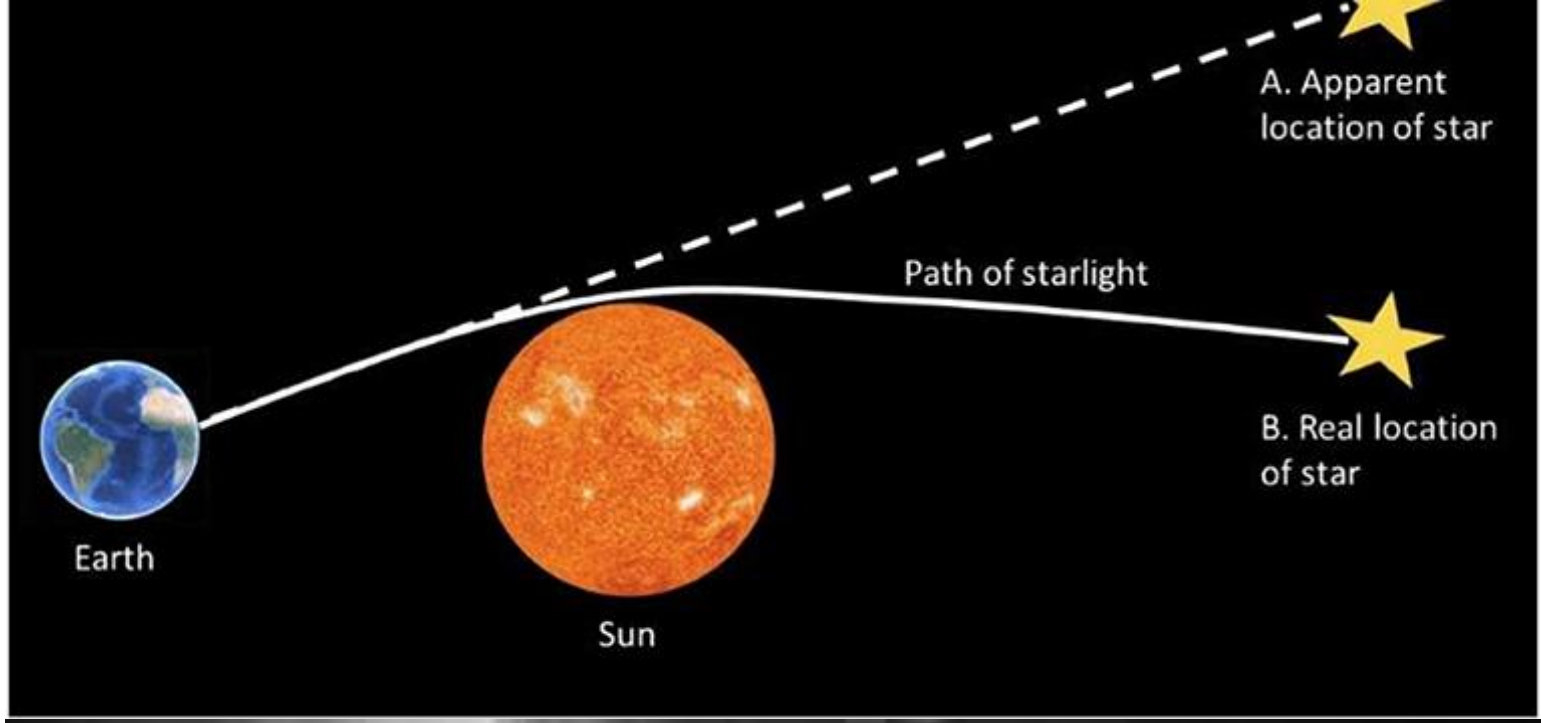


ALBERT EINSTEIN

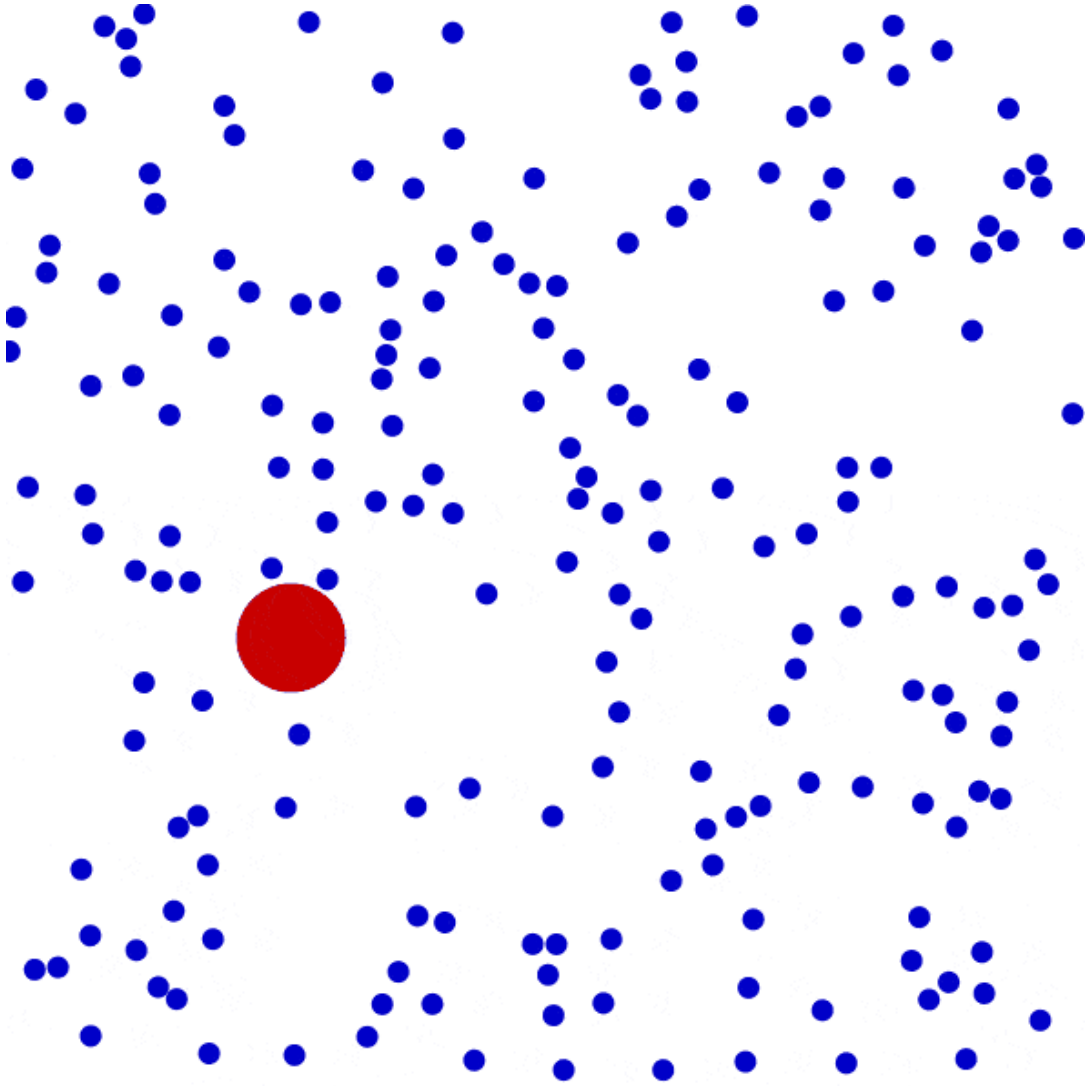
Developed the **Special** and **General** Theories of Relativity



Predicted bending of light during a solar **eclipse**



ALBERT EINSTEIN

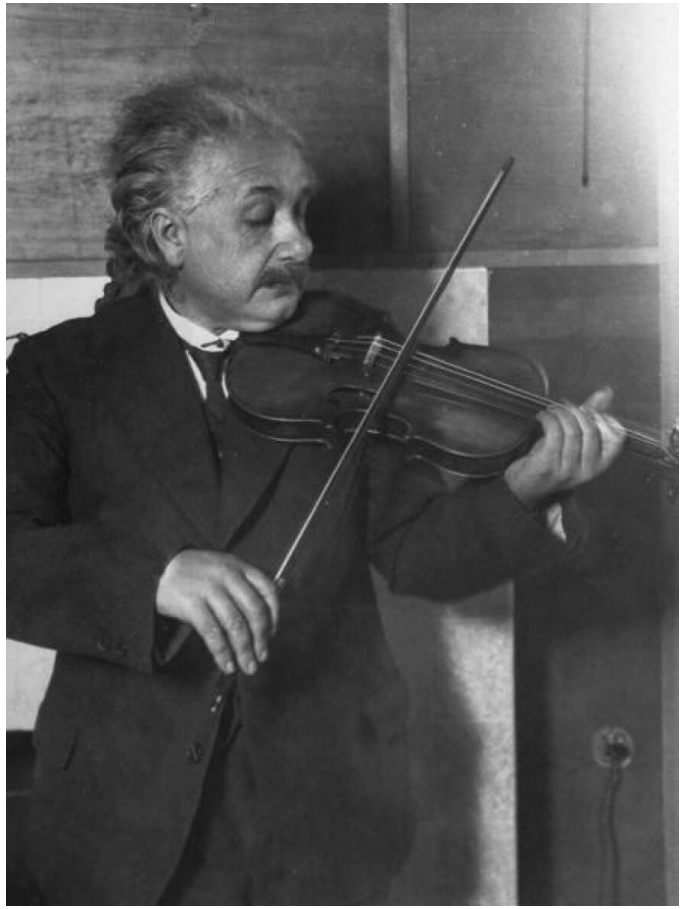


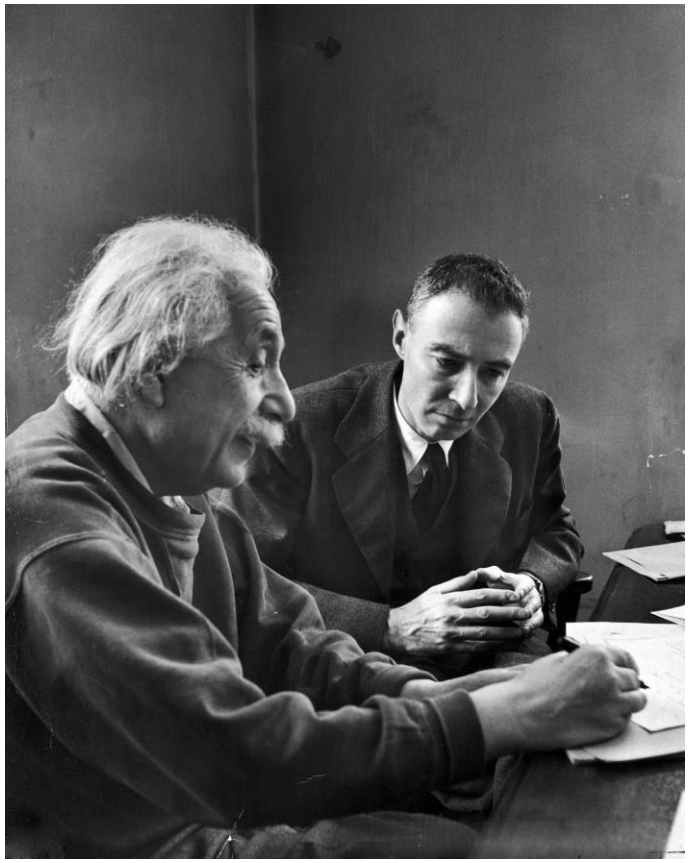
ALBERT EINSTEIN

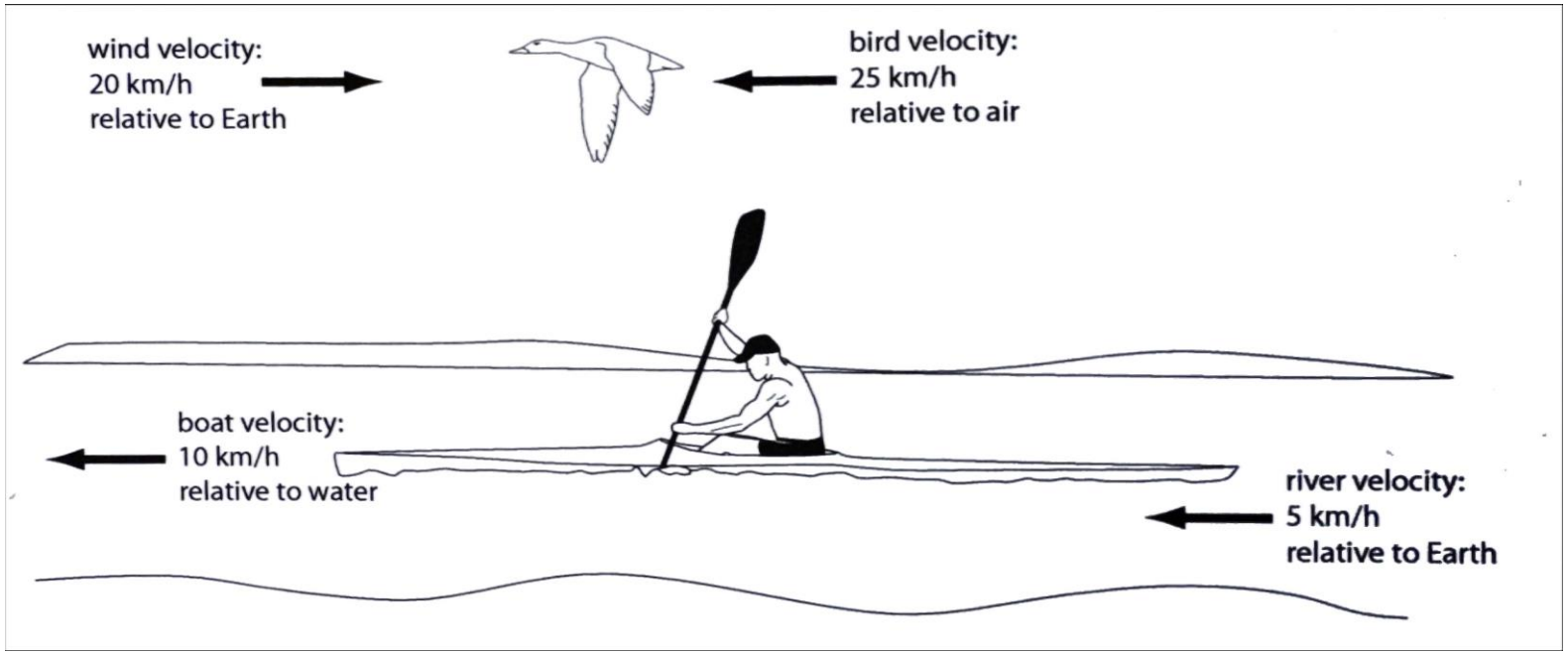
Proved existence of atoms (**Brownian** Motion)

ALBERT EINSTEIN

Later life spent **teaching** and researching in the U.S.



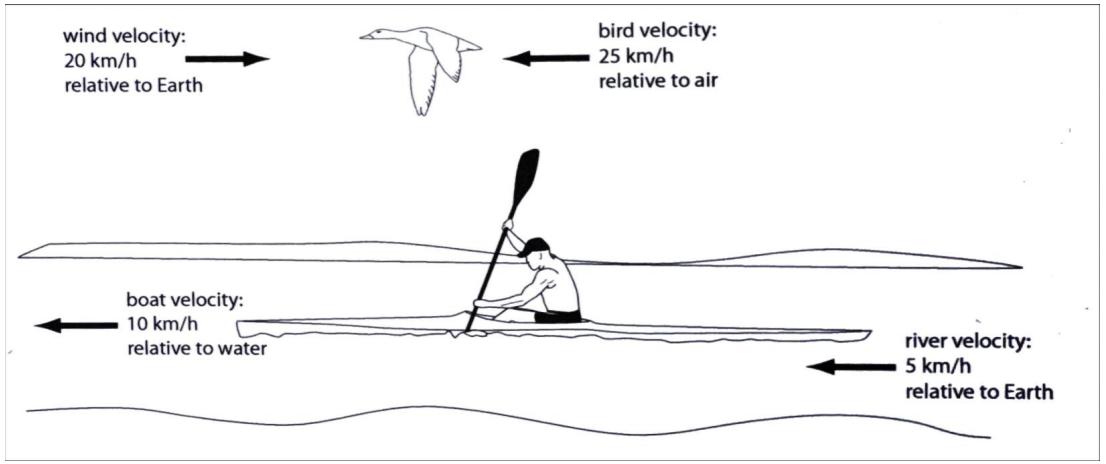




FRAMES OF REFERENCE

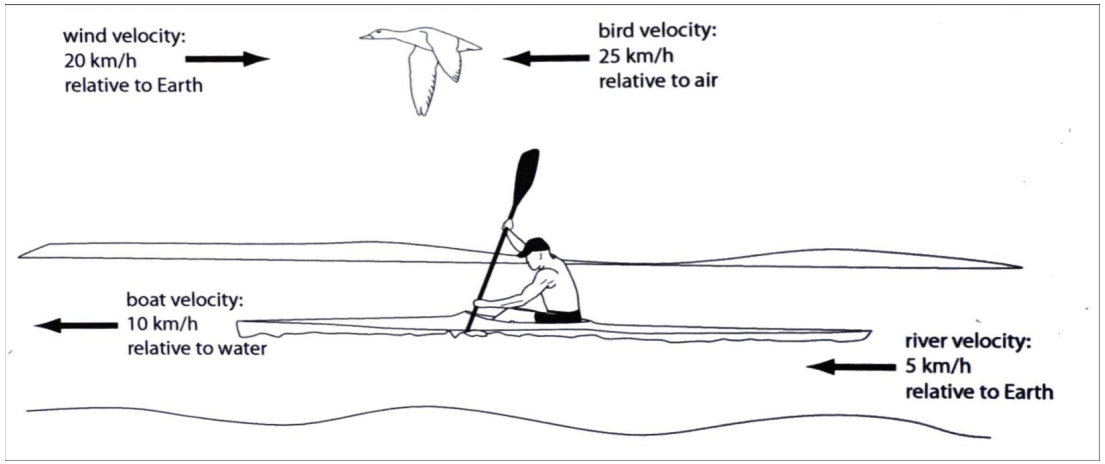
The position from which an **observer** views a particular event.

QUICK CHECK #1



1. What is the velocity of the person in the boat relative to:
   a) the water? 10 km/h downstream
   b) Earth's surface? 15 km/h downstream
2. What is the velocity of the bird relative to:
   a) the air? 25 km/h upstream
   b) the water? 20 km/h upstream
   c) the Earth's surface? 20 km/h upstream

QUICK CHECK #1 CONT'D



3. What is the velocity of the water relative to the bird?

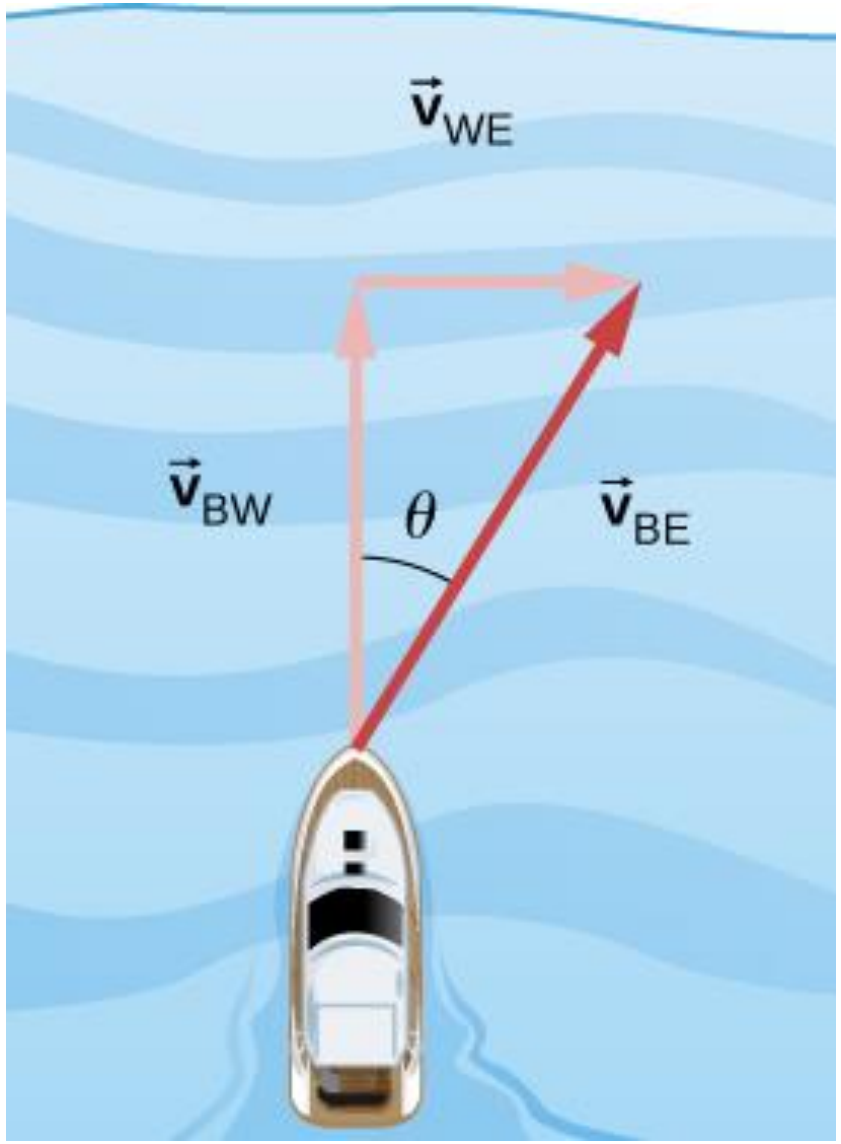
   20 km/h downstream

4. What is the velocity of the person in the boat relative to the bird?

   35 km/h downstream

5. What would all the velocities in the figure appear to be relative to a camera in a spy satellite in geosynchronous orbit? Its position is "fixed" relative to the point on the rotating earth?

   Earth's surface would appear fixed, so the same as everything relative to the Earth



RELATIVE MOTION

We have discussed relative motion in several units this semester.

Make a list of 5 things you are currently in relative motion to.

Order them from slowest to fastest:

DEVELOPING A SPECIAL THEORY OF RELATIVITY

Postulates and Concepts

CONDITIONS FOR SPECIAL RELATIVITY

- Einsteins special theory of relativity is based on **two** fundamental assumptions
- Fundamental assumptions = **postulates**
- The special theory of relativity deals only with frames of reference that are moving at **constant** velocity relative to each other.
  - No **acceleration**!

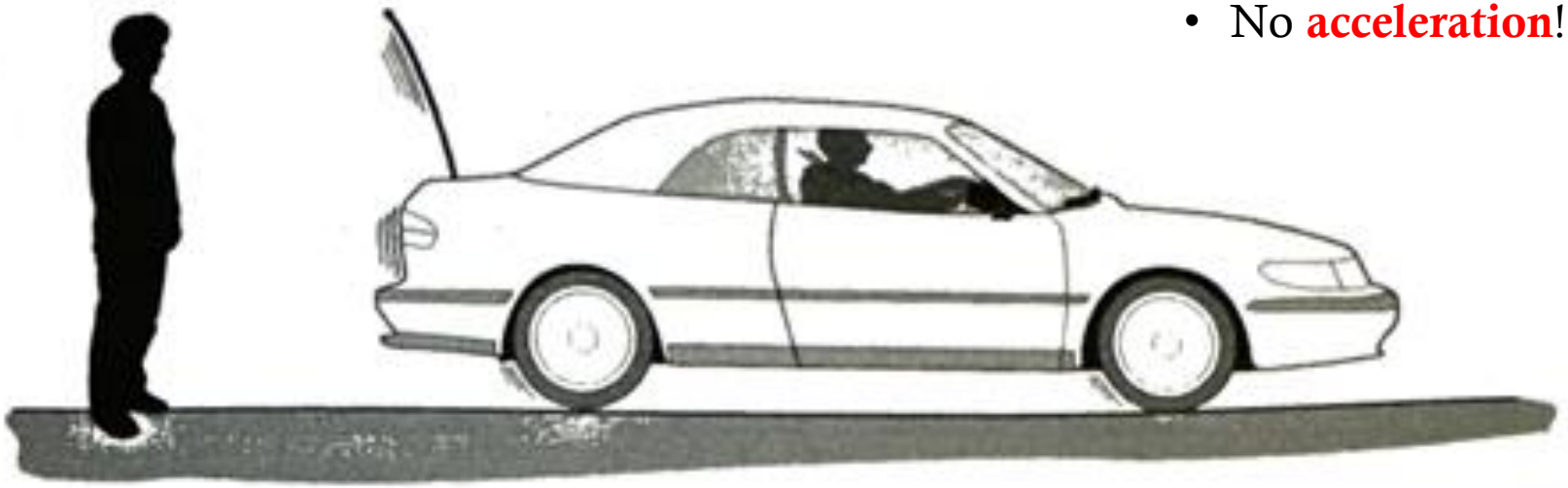


Figure 4.1.3 *The car is going 50 km/h relative to the person or the person is going 50 km/h relative to the car.*

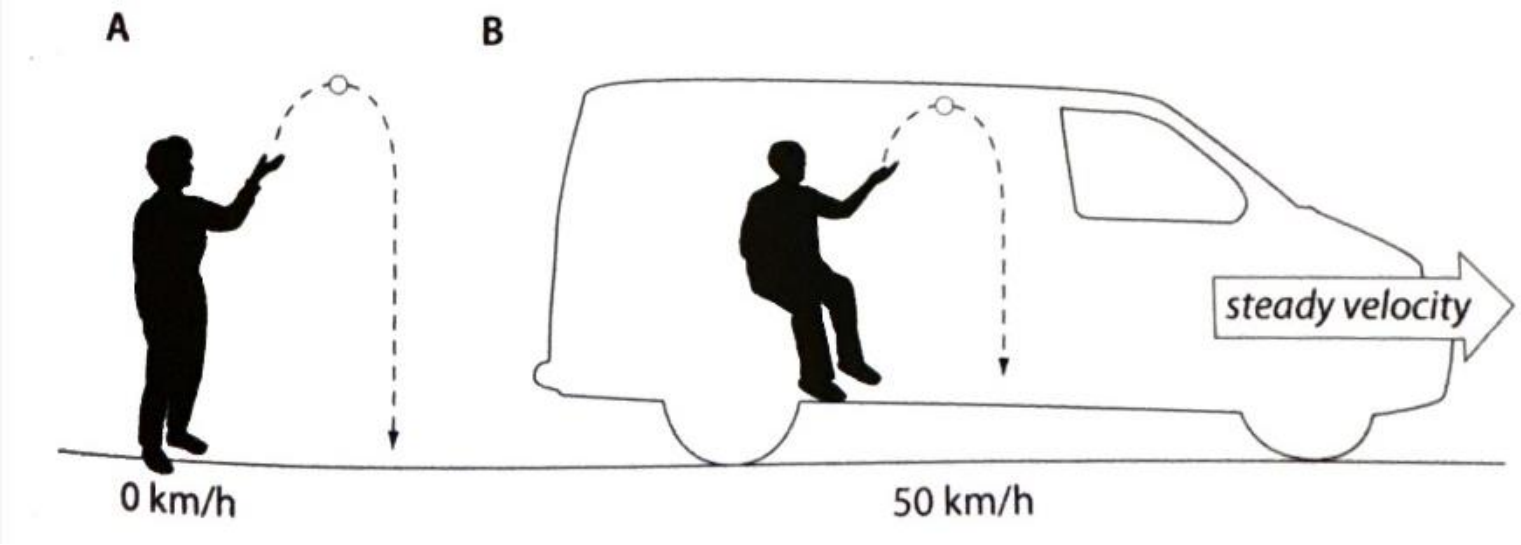
QUICK CHECK #2

Provide an example of two objects moving at constant velocity relative to each other (different from the example in the previous slide).

THE FIRST POSTULATE OF RELATIVITY

- The first postulate is called the **Special Relativity Principle:**
  - If two frames of reference move with constant velocity relative to each other, then the laws of physics will be the same in both frames of reference.

QUICK CHECK #3

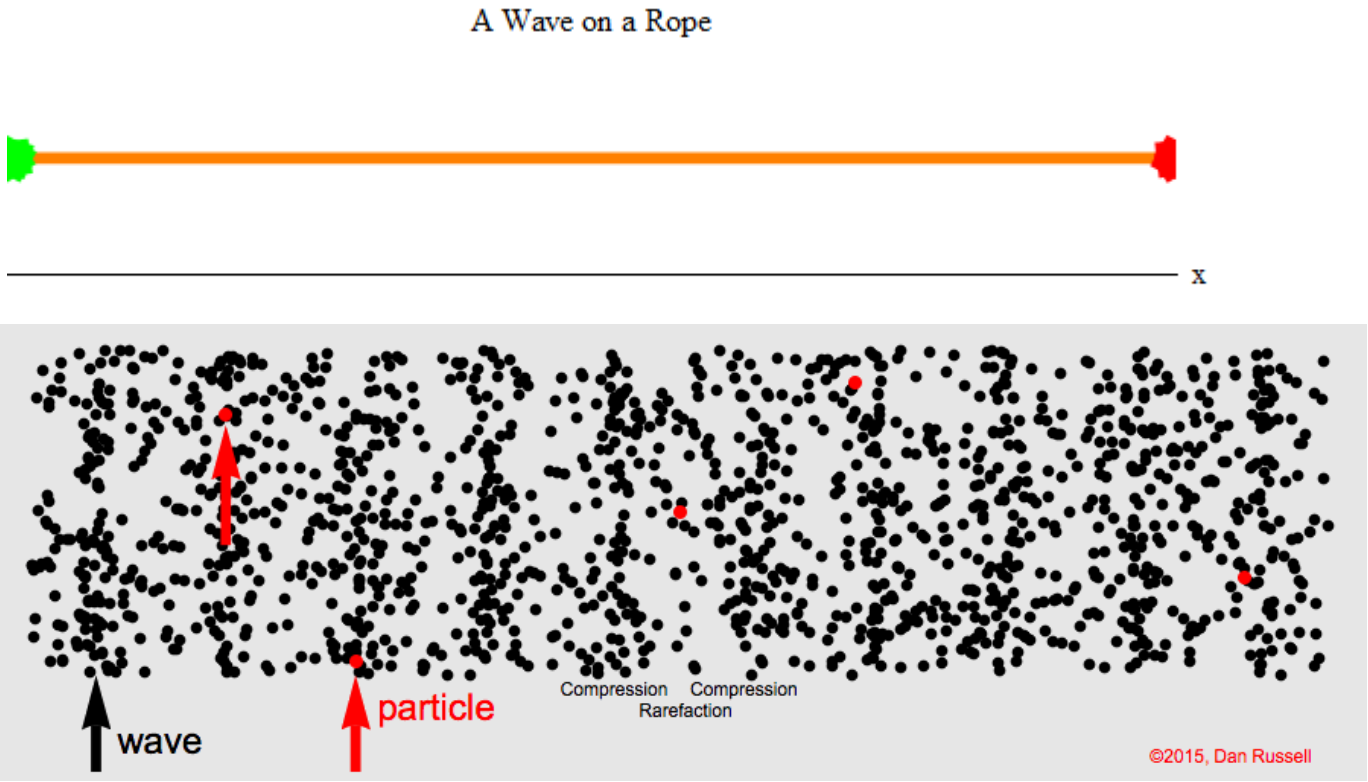


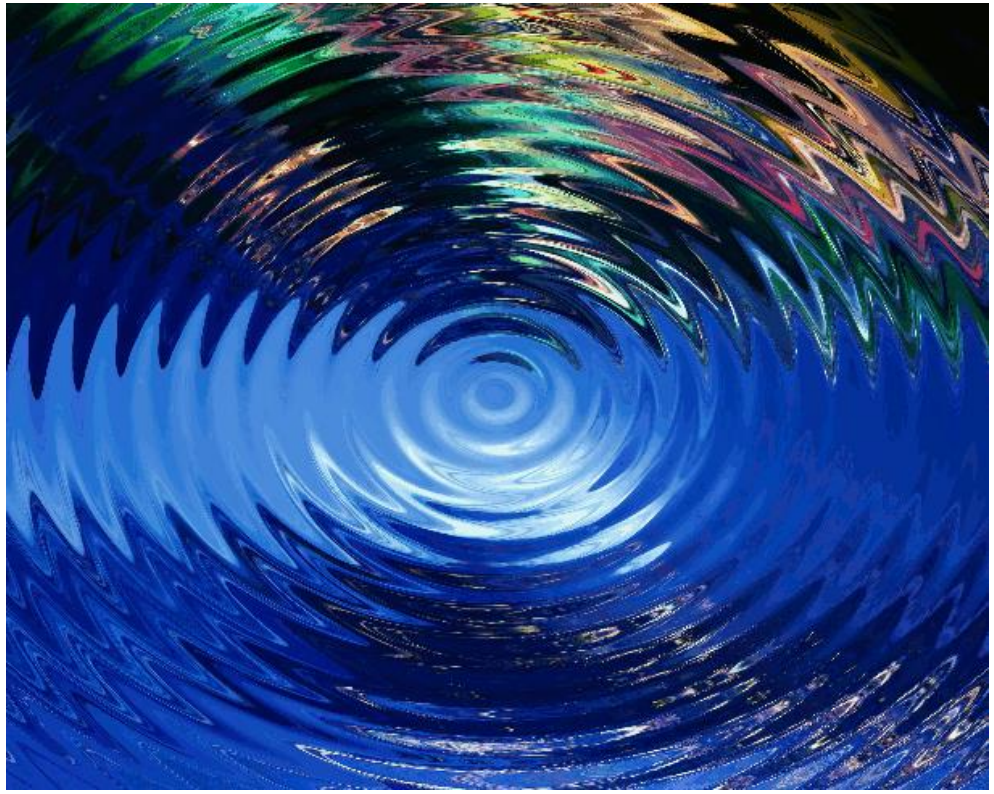
1. Both observers in the figure above are moving at constant velocity. What is the velocity of observer A relative to the road?
2. Sketch what the path of the ball thrown in the van would look like to an observer standing on the road looking into the van as it passes.


THE MICHELSON-
MORELY EXPERIMENT

CLASSICAL NOTION OF A WAVE

- A disturbance travelling through a **medium**

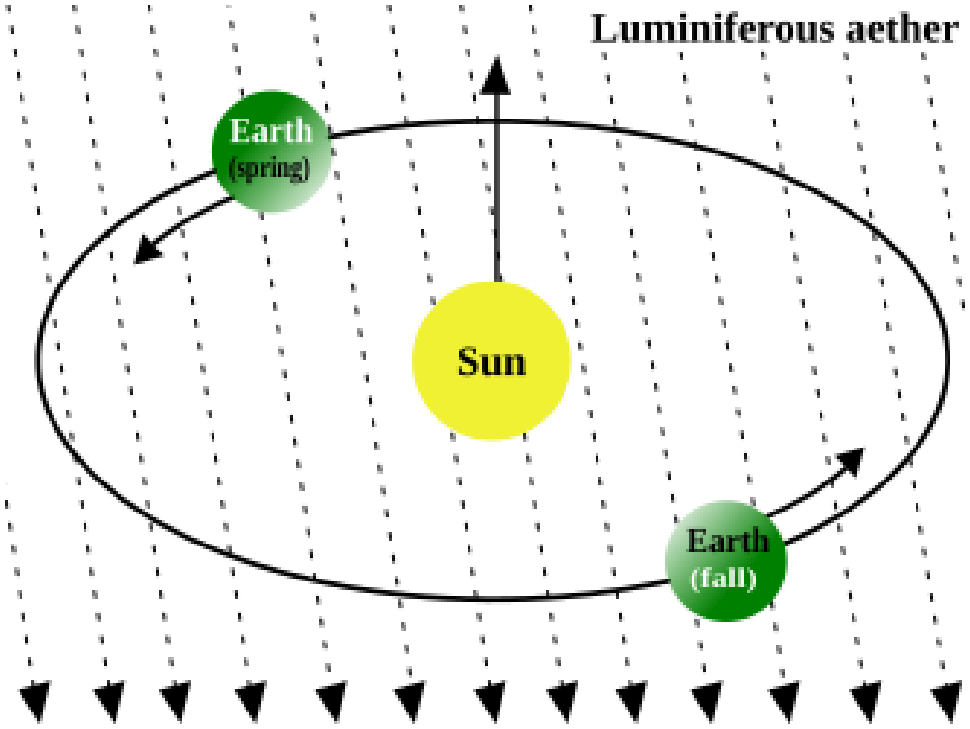




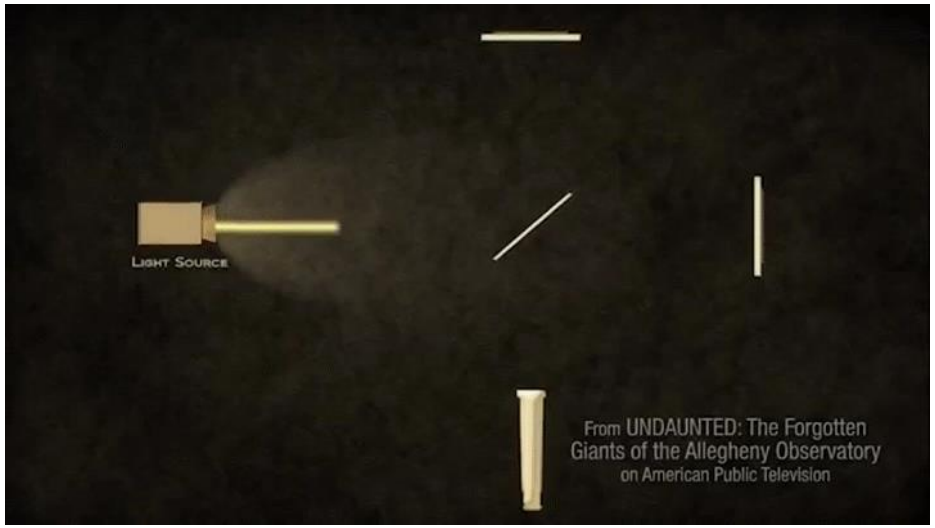
THE MYSTERIOUS BEHAVIOUR OF LIGHT

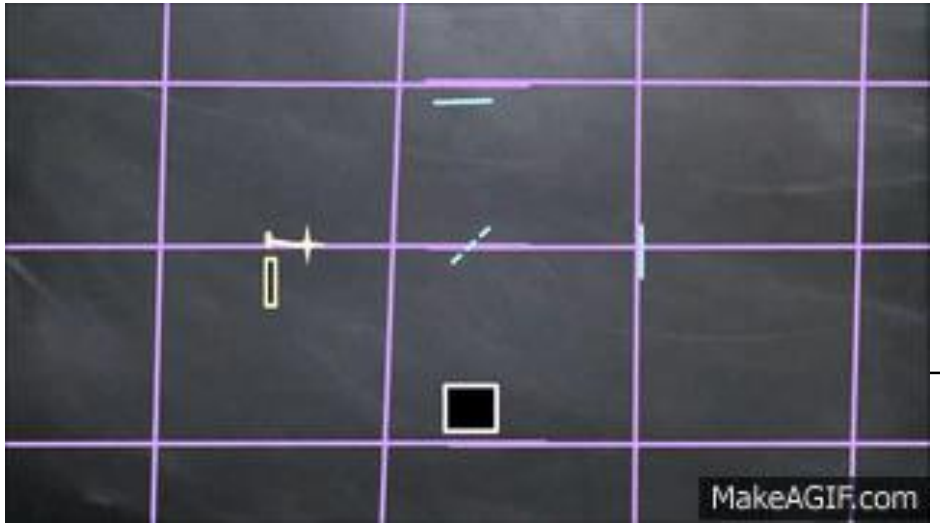
Thought process of the late 19th century:

- Light moves as a **wave**
- Waves move through **mediums**
- There must be a mysterious "something" that light moves through called the **luminiferous ether**
- This ether is likely the "**absolute reference frame**" – a reference frame from which everything in the universe moves relative to

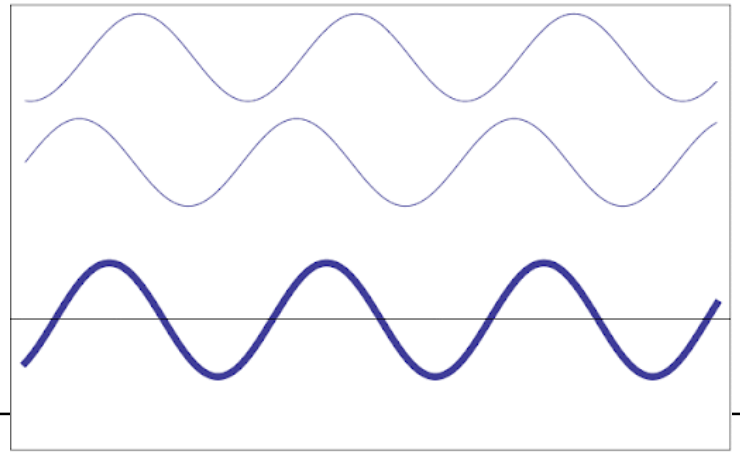


THE MICHELSON-MORELY EXPERIMENT

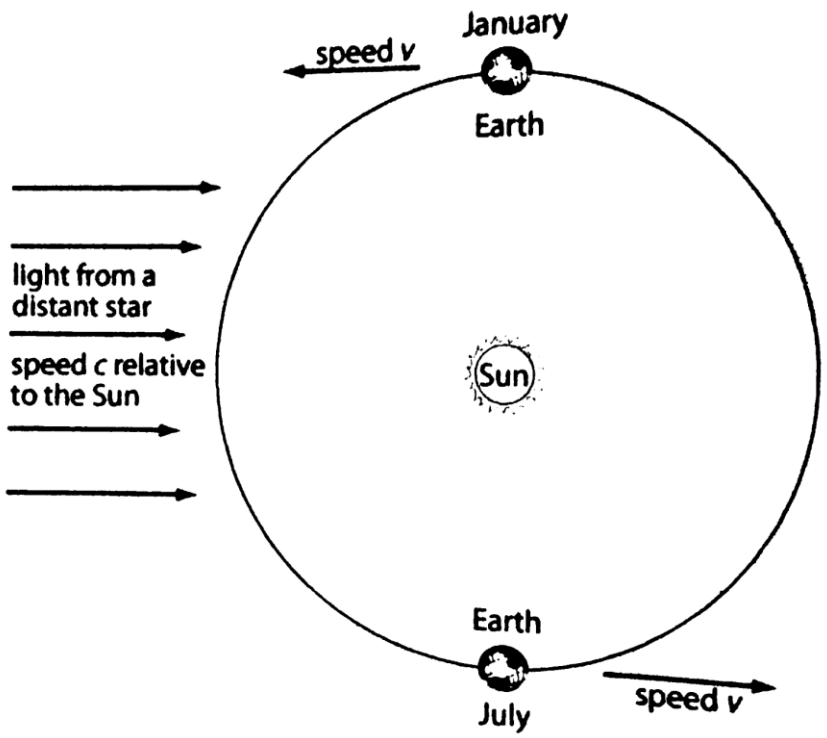




- Michelson–Morley tested whether light travels through an ether.
- A half-silvered **mirror** split light into perpendicular paths.
- No **interference** shift was observed.
- Conclusion: **no** ether; speed of light is **constant**.



THE MICHELSON-MORELY EXPERIMENT CONT'D



Another framing of the experiment:

- In January, the Earth moves **towards** the distant star with speed v relative to the sun.
  - Predicted speed: **c + v**
- In July, the Earth moves **away** from the distant star with speed v relative to the sun.
  - Predicted speed = **c – v**

- Measured speed (Jan & July) = **c**

SECOND POSTULATE OF RELATIVITY

Einstein predicted the **null** result of Michelson and Morley without being aware of their work.

He **never** believed in the existence of a fixed reference frame or ether.

Second Postulate:

- The **speed** of light in space is the same for any **observer** no matter what the velocity of the observer's frame of reference is, and no matter what the velocity of the source of **light** is.

QUICK CHECK #4

1. **A car is moving forward at 100 km/h. A passenger turns on a flashlight pointing forward.**

   What speed does the driver measure for the light?

   What speed does a stationary observer on the sidewalk measure?

2. **A spaceship moves at 0.8c relative to Earth. It emits a pulse of light forward.**

   What speed does the astronaut measure?

   What speed does the Earth observer measure?