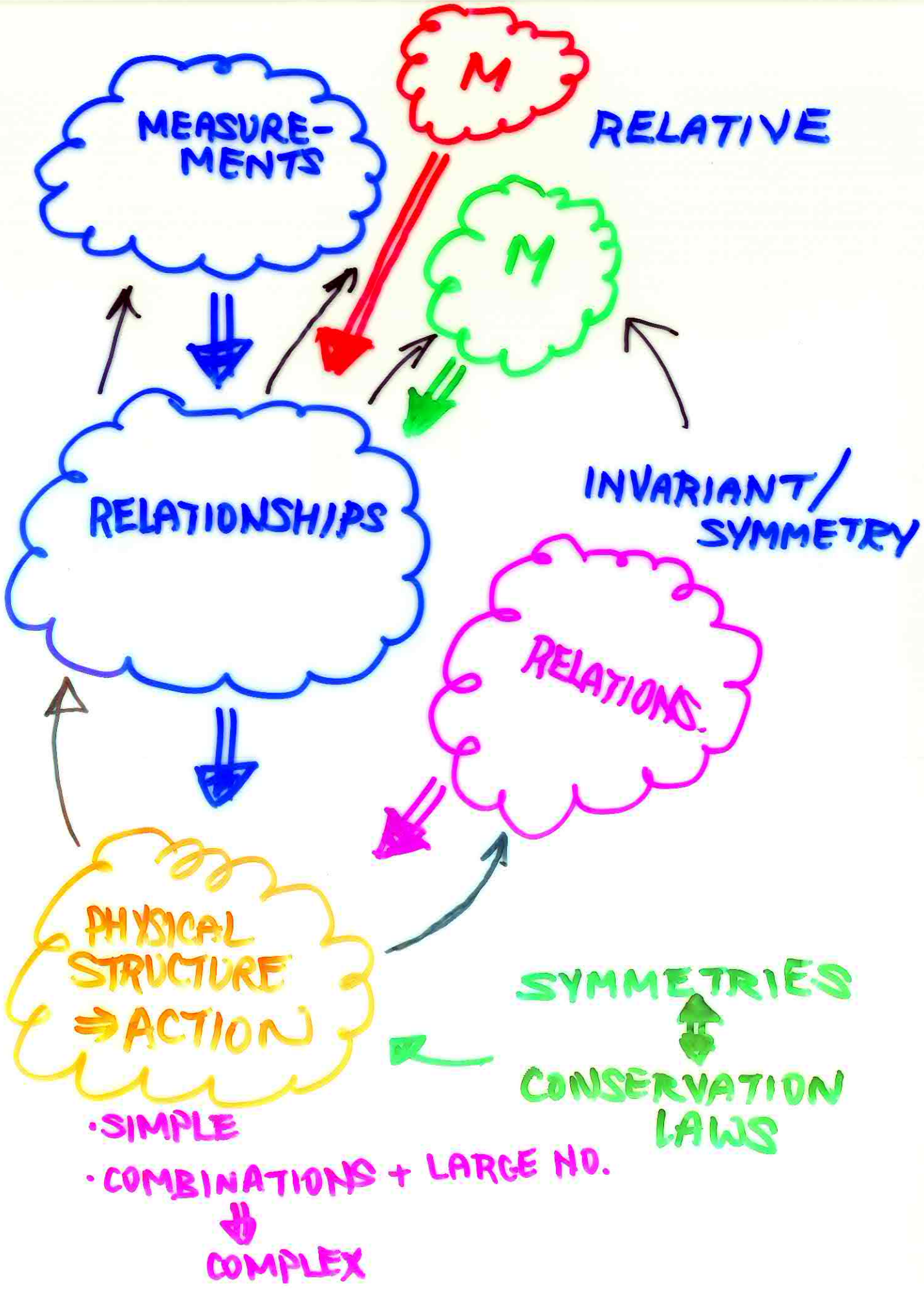

M
MEASURE-
MENTS
RELATIVE
M
RELATIONSHIPS
INVARIANT/
SYMMETRY
RELATIONS
PHYSICAL
STRUCTURE
⇒ACTION
SYMMETRIES
CONSERVATION
LAWS
·SIMPLE
·COMBINATIONS + LARGE NO.
⇓
COMPLEX

RELATIVITY [OF MEASUREMENTS]

- DID NOT ORIGINATE WITH EINSTEIN.

- HOW WOULD ONE SAY THAT SOMETHING WAS MOVING UNLESS YOU HAD ANOTHER OBJECT TO COMPARE AGAINST.

SUNG DYNASTY POET:

The boat looks red amidst the dancing flowers,
A hundred li of elms in a half-day's wind,
Reclining I watch the clouds stand still,
Not knowing the clouds and I both travel east.

Bishop BERKELEY [1685-1753]:
motion → distance between two objs. changing with time.

BUT WHICH OBJECT IS MOVING?
"convenience" "common sense because earth is huge"

But in space, two nearly equal objs?

In real life ⇒ jerks give us perception of motion [speeding up/down]

What about cruising steadily or at rest?

⇒ NO ABSOLUTE MOTION

→ FIRST DOCUMENTED EXPERIMENTS: GALILEO

GALILEAN TRANSFORMATION

GALILEAN, TRANSLATION, ROTATION

↓

AT HEART OF NEWTON'S LAWS OF MOTION

NEWTON'S LAWS OF MOTION

A] (1) Body at rest remains at rest unless acted upon by a force

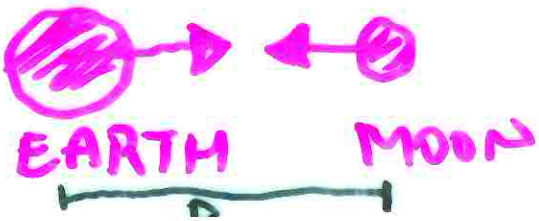
(2) Body moving in straight line at constant speed will continue to do so unless acted upon by a force

B] ACCELERATION IS PROPORTIONAL TO FORCE ACTING ON A BODY

$$F = ma$$

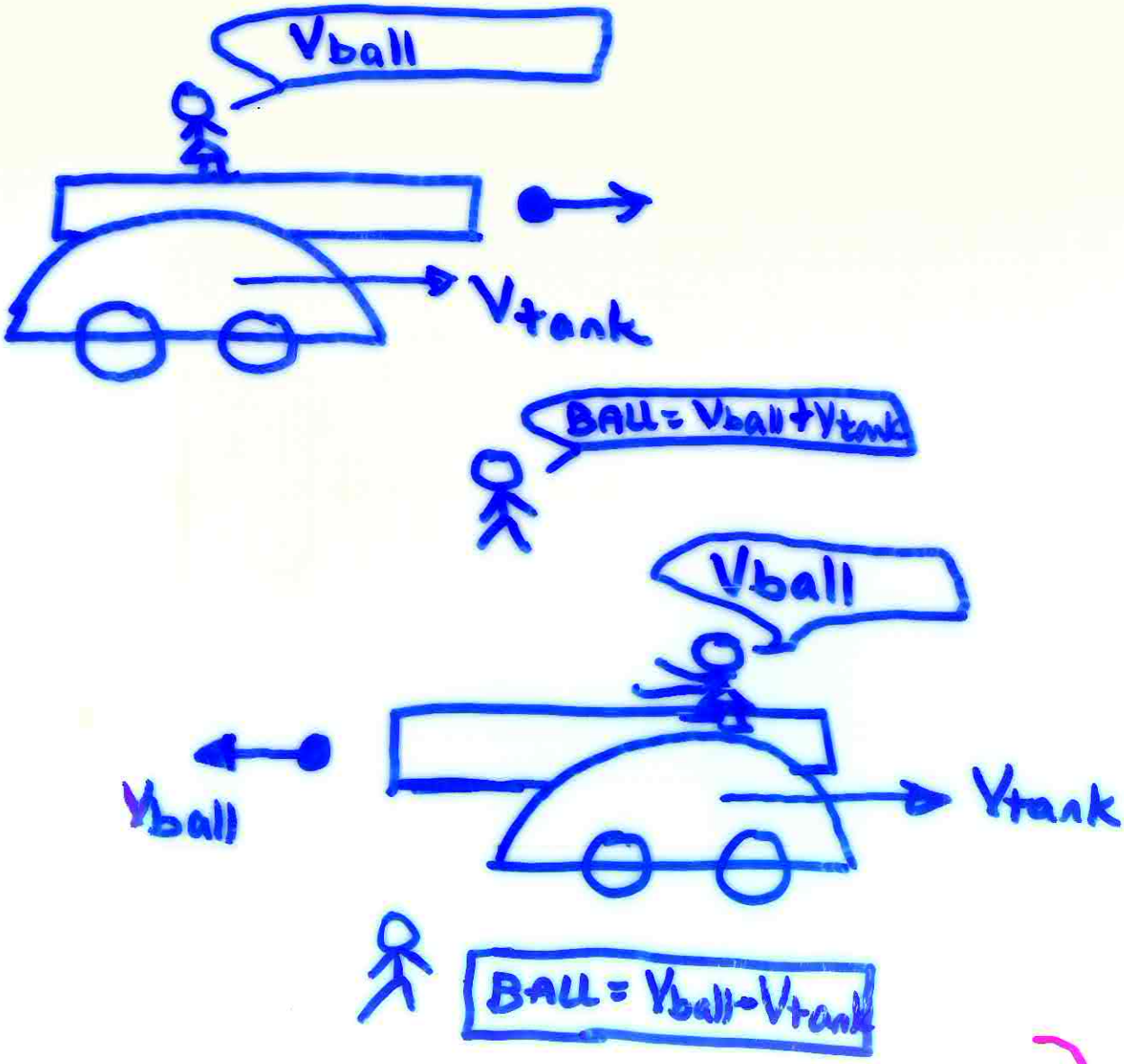
change in speed or direction with time

C] Whenever one body exerts a force on second body, the second exerts equal and opposite force back on the first



$$F_{grav} = \frac{G M_{earth} M_{moon}}{R^2}$$

NEWTONIAN MECHANICS

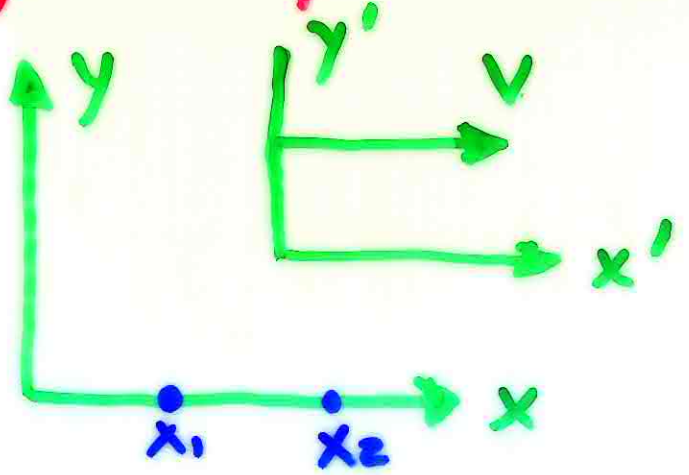


- OBJECTS MOVE IN ABSOLUTE SPACE
- MAY MOVE THRU IT DIFFERENTLY BUT EXPERIENCE IT SAME
- LENGTHS, WIDTHS, BREADTHS SAME
- TIME IS ABSOLUTE
- WE WILL ALL AGREE ON DURATIONS.

NEWTON

Newtonian Physics [1700-1800s]

- Objects moved in absolute space
- Objects experienced absolute time



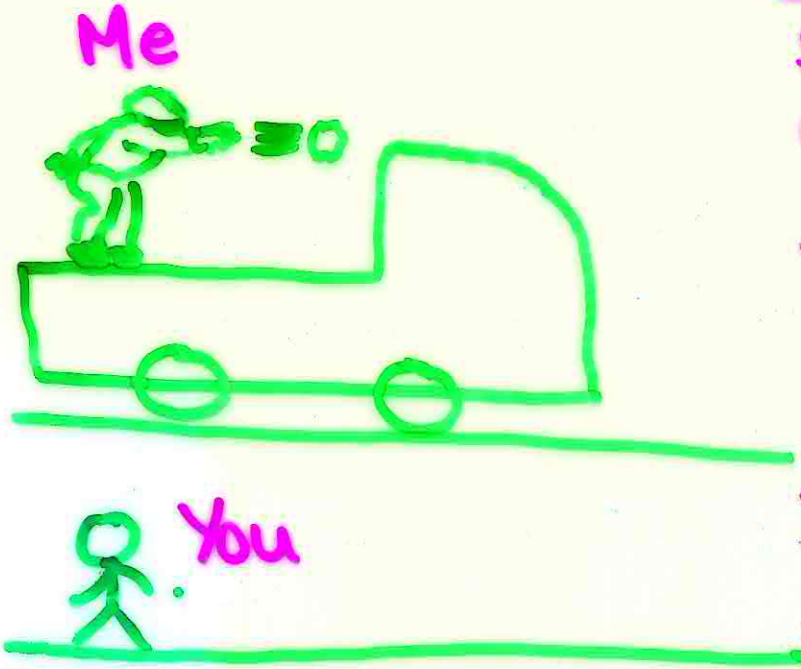
$$\text{Length} = X_2 - X_1$$

In moving frame [Assume two coincide at start

$$X_2' = X_2 - vt$$
$$X_1' = X_1 - vt$$

} Length $= X_2 - X_1$

⇑ same!



Imagine "me" standing on back of truck.

I throw a stone forward at 5 m/s

If truck is stopped how fast would you measure the rock to be moving?

ANSWER: 5 m/s.

If truck is moving forward @ 10 m/s

ANSWER: 5+10 = 15 m/s

What if truck was moving backward at 10 m/s?

Answer: 5-10 = -5 m/s

You'd actually see rock moving backward!

MAXWELL & ELECTROMAGNETIC THEORY.

[1700-1800]

Electric & Magnetism:

- LODESTONE & AMBER
- 1785 COULOMB FORCE BET. CHARGES
- 1789 Galvani dissecting frog
  ⇒ current (twitch)
- Volta → battery [chemical Rx]
- OERSTED CURRENT CAUSES MAGNETIC FIELDS.

- FARADAY : moving charge is current
  Voltage [coulomb force] → mot.

MAXWELL (1850s):

Accumulated & summarized all known facts:

IN VACUUM.

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

$$\vec{\nabla} \cdot \vec{E} = 0$$

$$\vec{\nabla} \times \vec{B} = \varepsilon_0 \mu_0 \frac{\partial \vec{E}}{\partial t}$$

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

COMBINED THESE TO DISCOVER LIGHT.

$$\frac{\partial^2 \vec{E}}{\partial t^2} - \frac{1}{\varepsilon_0 \mu_0} \nabla^2 \vec{E} = 0$$

Whose speed is $c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$

* IN VACUUM, ONCE EMITTED, SPEED IS INDEPENDENT OF SOURCE SPEED !!

COMPARE TO ROCK & TRUCK.

MOREOVER μ_0, ϵ_0 ARE CONSTANTS THAT DESCRIBE NATURE OF "MEDIUM" IN WHICH THIS WAVE PROPAGATES.

IF OBSERVER IS MOVING, GALILEAN TRANSFORMATION SAYS

$$c' = c \pm v$$

BUT THIS WOULD IMPLY μ_0', ϵ_0'

IE: MOVING OBS WOULD EXPERIENCE VACUUM DIFFERENTLY

$\therefore$ INERTIAL FRAMES NOT ALL EQUAL!

OR

MAXWELL IS RIGHT, RELATIVITY/EQUIVALENCE IS RIGHT BUT GALILEAN TRANSF. IS NOT SYMMETRY OF NATURE!