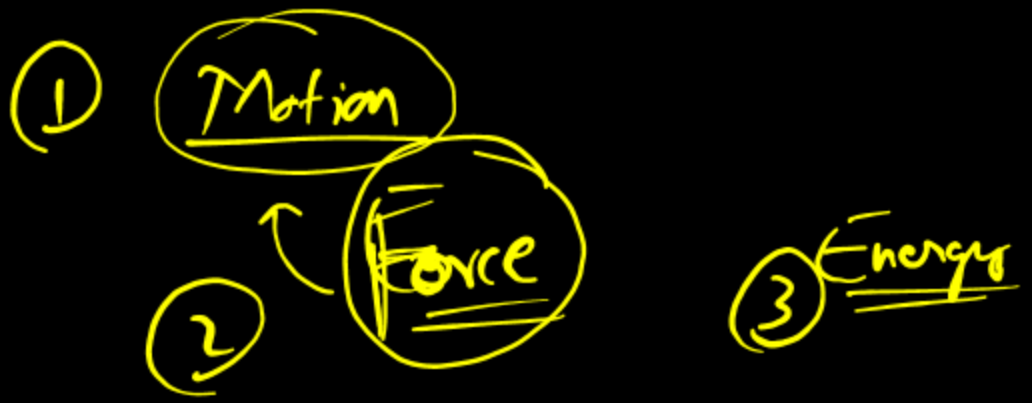
Motion and Forces

Forces and Motion and Energy (Work & Energy)



Force

↳ Push or Pull

Types of forces

- Gravitational force
- Normal force
- Applied force
- Friction force
- Electromagnetic force
  ↳ forces exerted by charges at rest/motion.

Rest and Motion

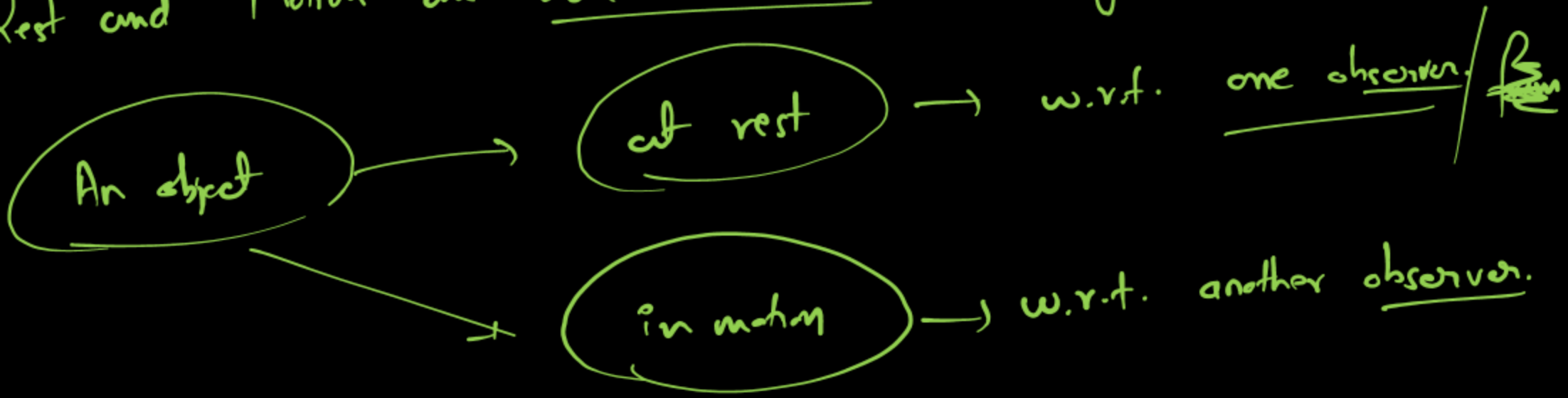
Rest: An Object is said to be at rest, if its position does not change with respect to its surrounding with time.

↓

frame of reference.

Motion: An object is said to be in motion, if its position changes with time w.r.t. its surrounding

Rest and Motion are relative term, as they



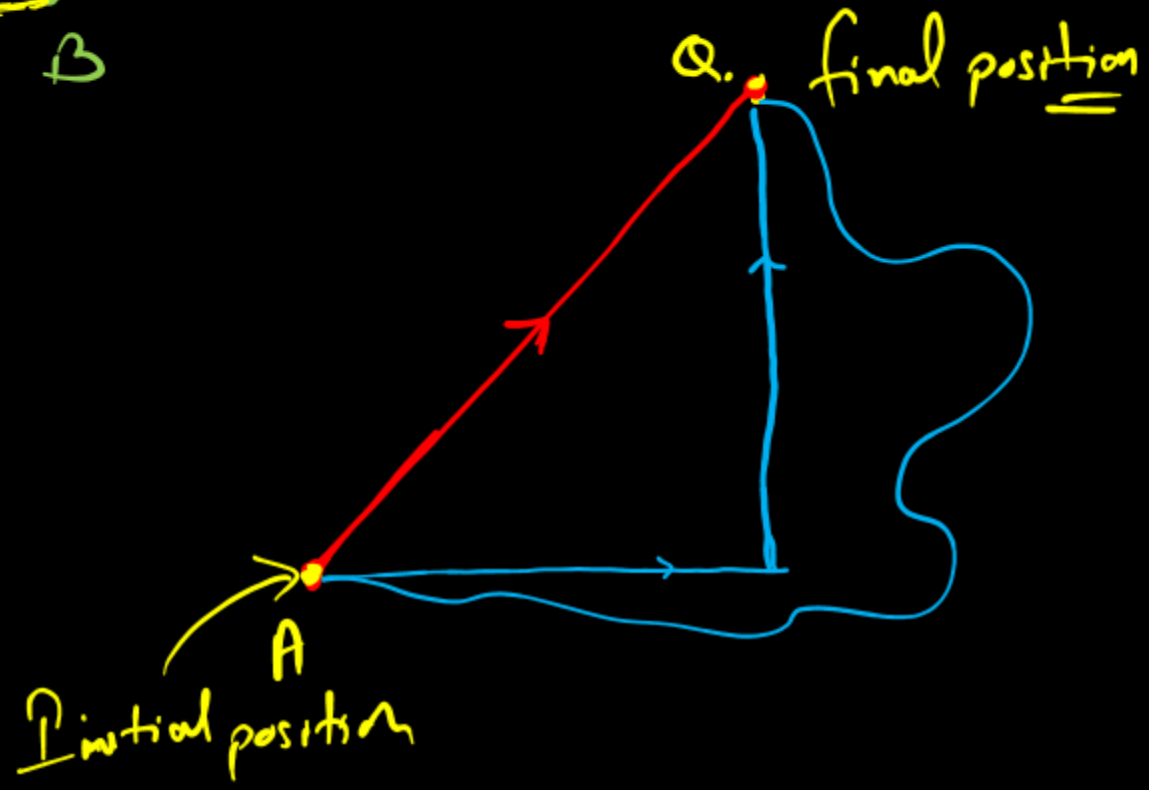
Types of motions

1. ⇒ Translatory motion ← Daily: ⟶
   - ↳ motion on straight path / or curved path.
2. Circular Motion / Rotatory motion :
   - ↳ Along a circular path / Rotation of earth
3. Oscillatory motion / Vibration
   - ↳ motion of a swing / pendulum

Distance and Displacement

- Distance → Shortest distance between two points.
- Displacement → Directional.

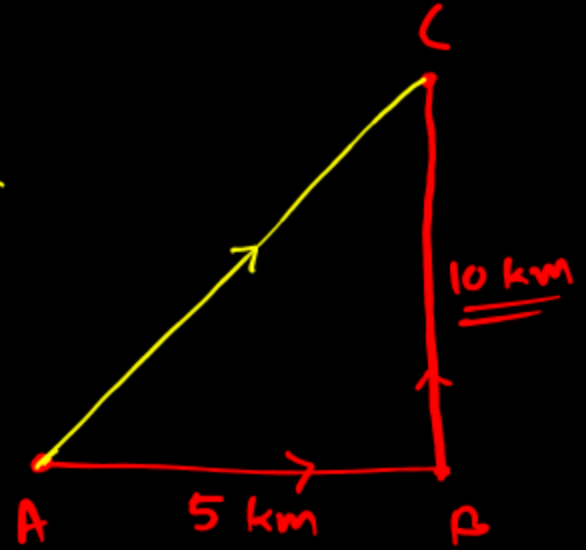
- Actual path length covered
- Not directional

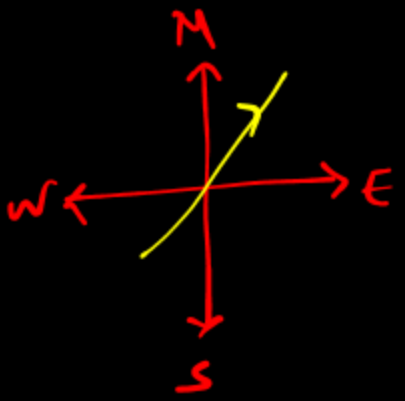


Displacement from A to C

$AC = \sqrt{5^2 + 10^2}$

$= \sqrt{125}$ km → Along AC: towards north-east





Displacement ⇒ Zero, +ve, -ve

↑ direction

Time :

Duration

SI Unit : seconds

Other units : minute, hour, day, week, months, years, ...

Light year ⇒ unit to measure distance.

↳ Distance travelled by light in one year.

Speed of light = 3×10^8 m/s.

⇒ H.W. How much distance (km) light travels in 1 year (km).

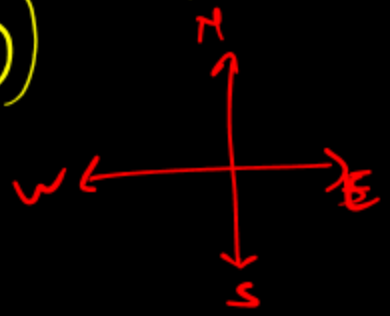
Speed :

"Distance covered in unit time."

$$\text{Speed} = \frac{\Delta x}{\Delta t}$$

$$\text{Speed} = \frac{\text{Change in distance}}{\text{change in time}}$$

(m/s)



Velocity : "Displacement in unit time"

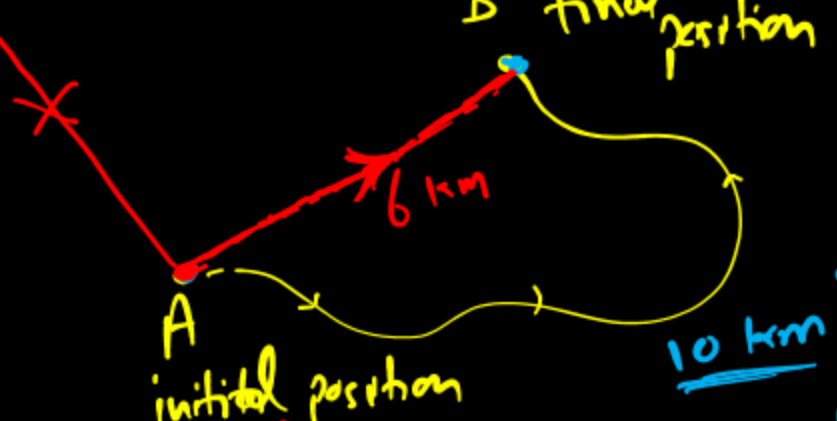
(direction)

→ [Speed + direction]

m/s

$$\Rightarrow \frac{\text{total displacement}}{\text{total time}}$$

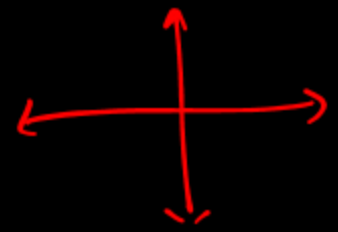
$$= \frac{6 \text{ km along N.E.}}{2} = 3 \text{ km/h in N.E direction}$$

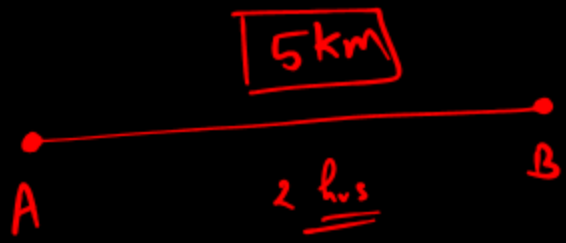


10 km & in 2 hours.

$$\text{Speed} = \frac{10 \text{ km}}{2 \text{ h}} = 5 \text{ km/h}$$

Average velocity = $\frac{\text{Total displacement}}{\text{total time}}$





Avg. Speed = $\frac{5 \text{ km}}{2 \text{ hr}} = 2.5 \text{ km/hr}$

Avg. velocity = $\frac{5 \text{ km from A to B}}{2 \text{ hr.}}$

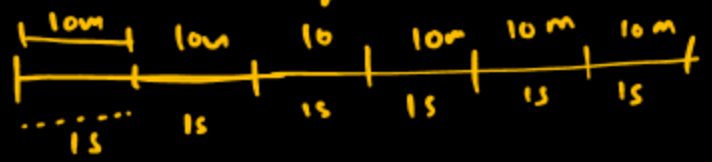
$= 2.5 \text{ km/hr}$ from A to B.

Speed $\left(\frac{\text{Distance}}{\text{time}}\right)$

Types of Speed

(i) **Uniform Speed:** "Equal distance in equal intervals of time".

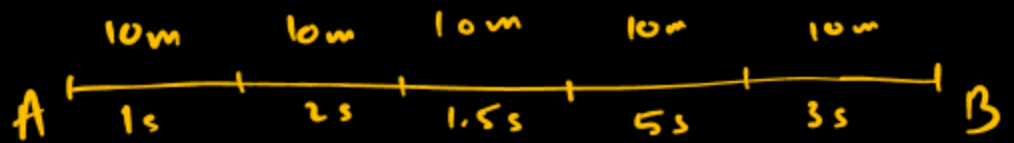
e.g. 10 m in 1 sec



(ideal)

(ii) **Non-uniform Speed:** "Equal distance in unequal intervals of time"

(Real)



$$\text{Avg. Speed} = \frac{\text{Total distance}}{\text{total time.}}$$

Velocity $\left(\frac{\text{Displacement}}{\text{time}}\right)$

Types of velocity (Speed / Direction)

(i) **Uniform velocity:**

"When a body moves with uniform speed in a fixed/specific direction, it is said to be in uniform velocity."

(ii) **Non-uniform / Variable velocity:**

When speed or direction or both changes during motion.

$$\Rightarrow \text{Avg.} \quad \text{Average Velocity} = \frac{\text{Total displacement}}{\text{total time.}}$$

"Acceleration"

~~Circular motion~~

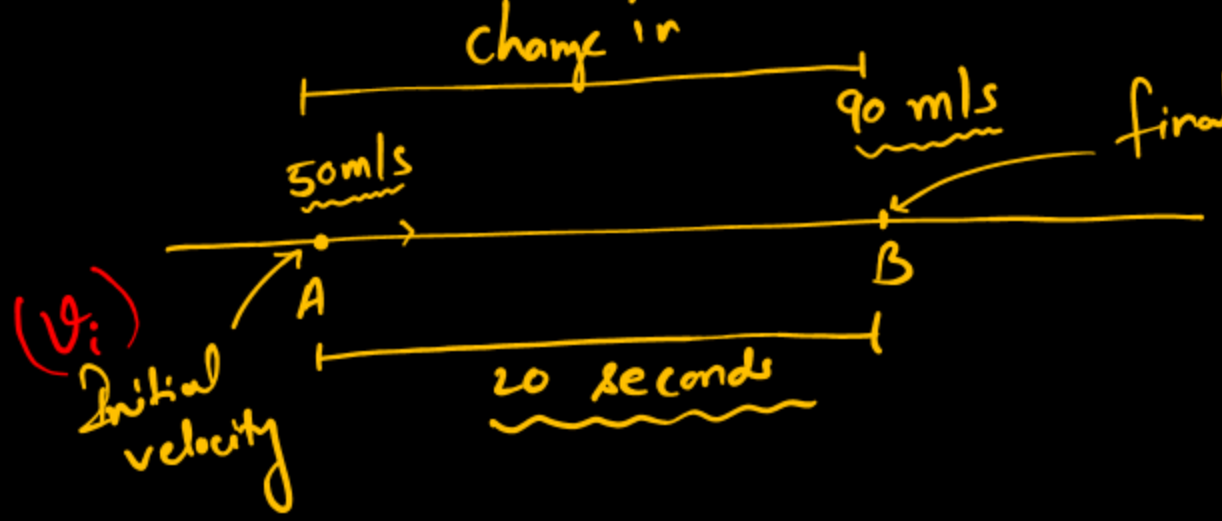
Forces & Laws of motion.

$$F = m \cdot a.$$

$$a = \frac{F}{m}$$

acceleration.

Acceleration (a): Rate of change of velocity per unit time.



Change in velocity from A to B = $\oplus 40$ m/s

time taken for this change to happen = 20 s.

$$a = \frac{\text{change in velocity}}{\text{time it took for the change}}$$

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{(90 - 50)\ \text{m/s}}{20\ \text{s}}$$

$$= \frac{40\ \text{m/s}}{20\ \text{s}}$$

$$= \frac{2\ \text{m/s}}{1\ \text{s}}$$

$$= 2\ \text{m/s}^2 = 2\ \text{m/s}^2$$

S.I. Unit of acceleration (m/s^2)

$$a = \frac{\text{change in velocity}}{t}$$

$$= \frac{v_f - v_i \ (\text{velocity})}{t}$$

$$= \frac{\text{unit of velocity}}{\text{unit of time}}$$

$$= \frac{m/s}{s}$$

$$= m/s \div s$$

$$= \frac{m}{s} \times \frac{1}{s}$$

$$= \frac{m}{s \times s}$$

$$= \frac{m}{s^2}$$

$$= m/s^2$$

$$= m s^{-2}$$

Negative acceleration

Retardation

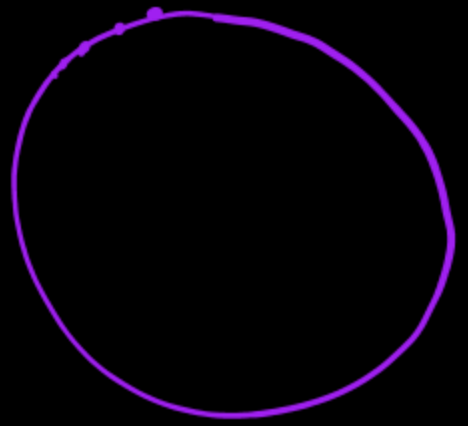
Deacceleration

$m/s = \frac{m}{s}$

If velocity is uniform, ⇒ No change in velocity.

Hence, no acceleration.

⇒ Circular motion is always accelerated motion.



$$a = \frac{\text{change in } v}{\text{time}}$$

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{0}{t}$$

$$a = 0$$

Force

- To move a stationary object from one place to another, we need to put some effort. This effort is known as force.
  - For Example, a push, a hit or a pull.

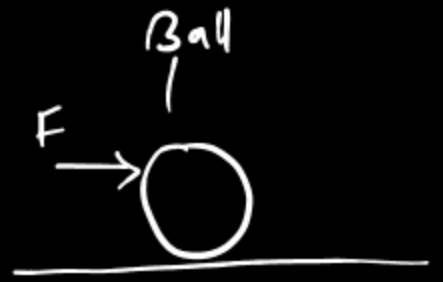
Definition:
An external effort in the form of push or pull that changes or tends to change the state of rest or of motion, or direction, or dimension of the body.

Shape

Effects of Force

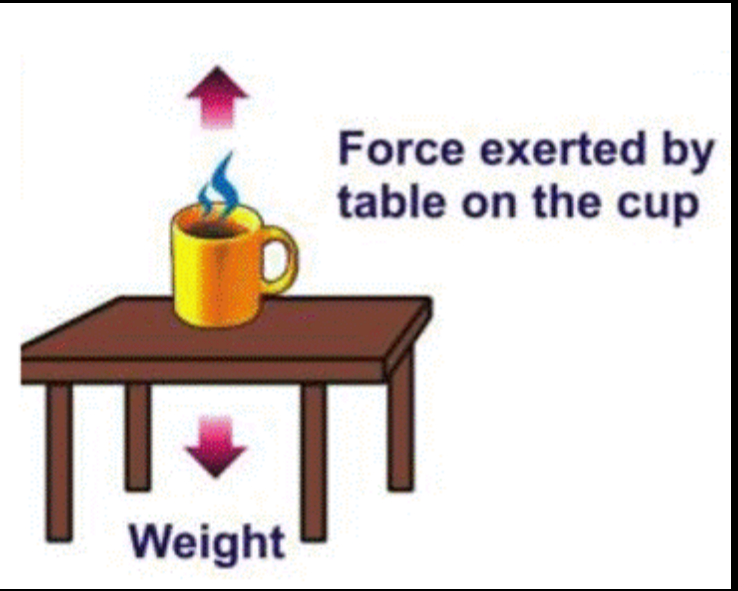
Force can:

- initiate motion in a motionless object.
- change (increase or decrease) the velocity of the moving object
- alter the direction of a moving object.
- change the shape and size of an object.



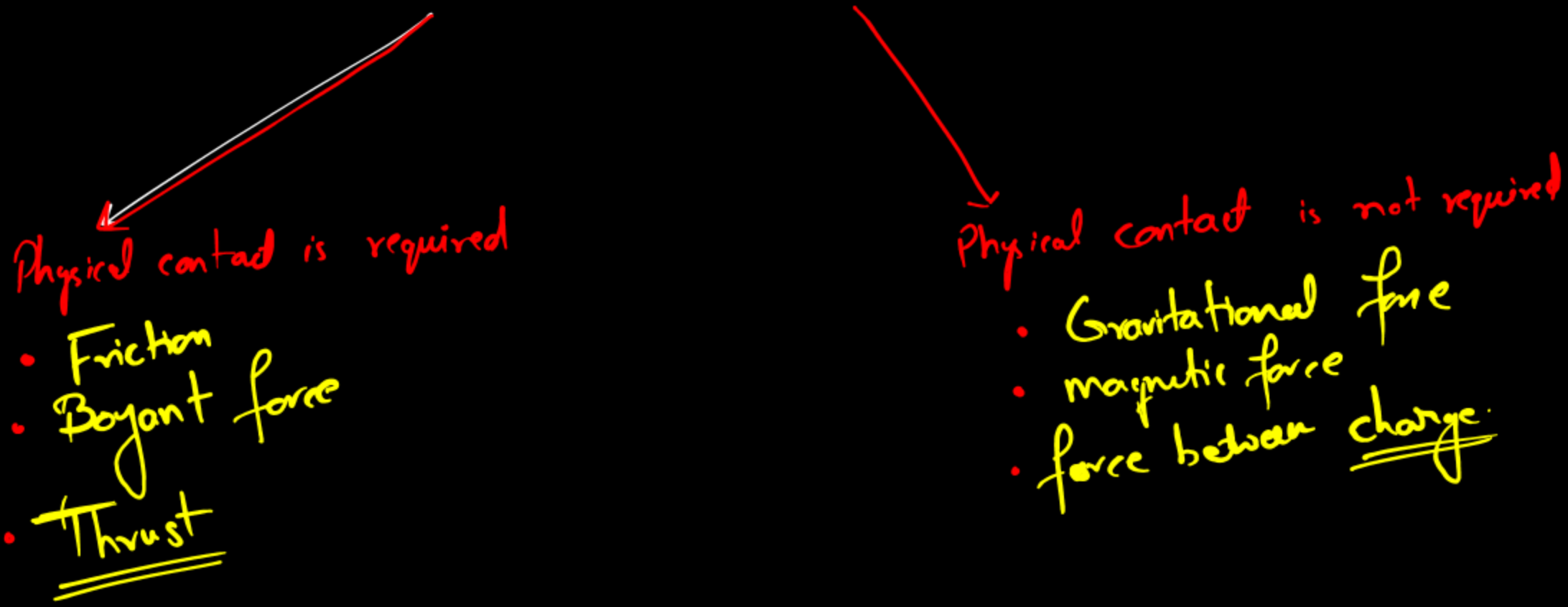
Types of Forces: Balanced and Unbalanced Force

- Balanced Forces :- When equal amounts of forces are applied to an object from different directions such that they cancel out each other, such forces are known as balanced forces.
  - Balanced forces do not change the state of rest or motion of an object.
  - Balanced forces may change the shape and size of an object.



- Unbalanced Force – When forces applied to an object are of different magnitude (or not in opposite directions to cancel out each other), such forces are unbalanced forces.
  - Unbalanced forces can alter the state of rest or motion of an object.
  - Unbalanced forces can cause acceleration in an object.
  - Unbalanced forces can change the shape and size of an object.

Types of Forces: Contact and Contactless force



Formula of Force

applied by an object of mass 'm' (kg) having acceleration 'a' m/s²

$$F = m \times a$$

Force = mass × acceleration

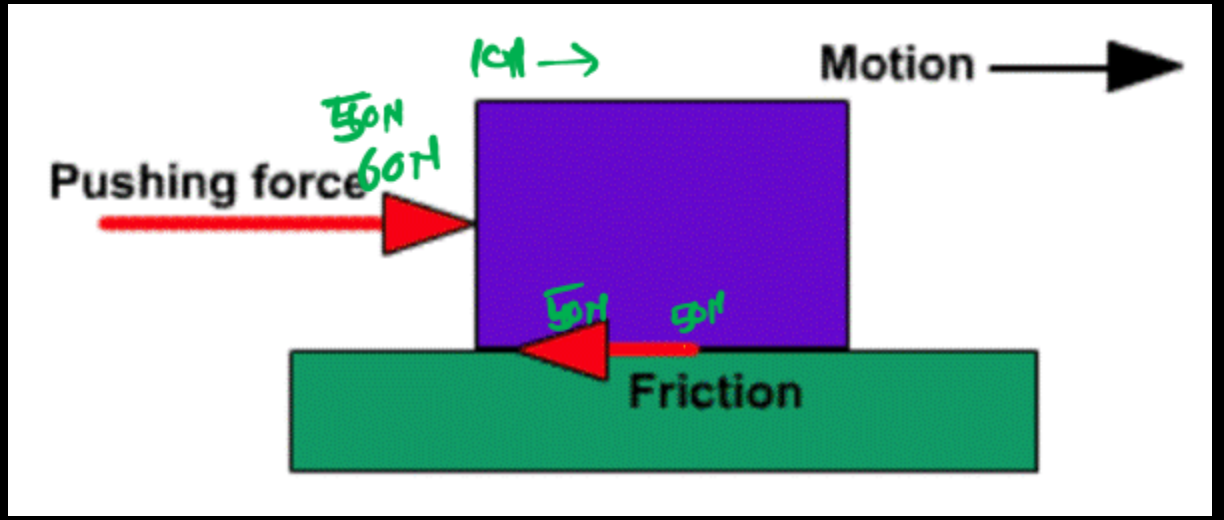
Rate of a = Change of velocity.

F = ma

Result derived from Newton's second law of motion.

Friction

- It is a force extended when two surfaces are in contact with each other.
- It always acts in a direction opposite to the direction of motion of the object.



depends on roughness of the surface

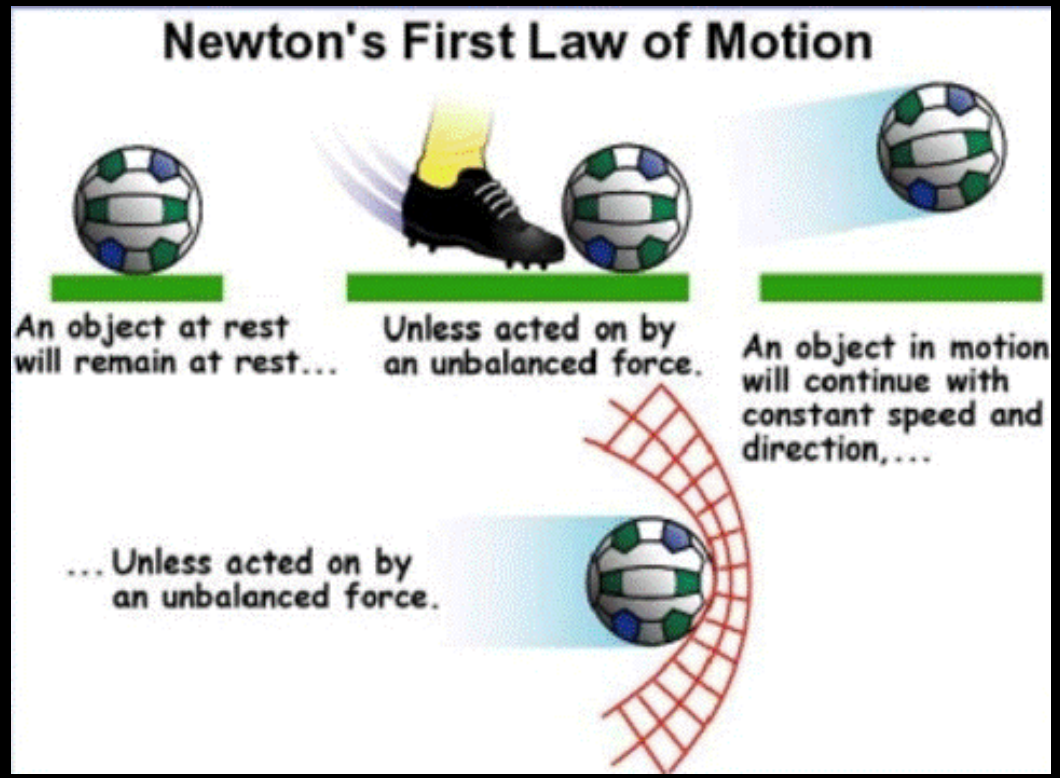
Laws of Motion

Newton’s Laws of Motion

First Law of Motion (Law of Inertia)

- An object remains in a state of rest or of uniform motion in a straight line unless compelled to change that state by an applied force.
- In other words, all objects resist a change in their state of motion or rest.
- The tendency of an object to stay at rest or to keep moving with same velocity is called inertia.

Inertia $\propto$ mass



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- In other words, all objects resist a change in their state of motion or rest.
- The tendency of an object to stay at rest or to keep moving with same velocity is called inertia.
- First Law gives qualitative definition of force.

Inertia (First law of motion) in everyday life

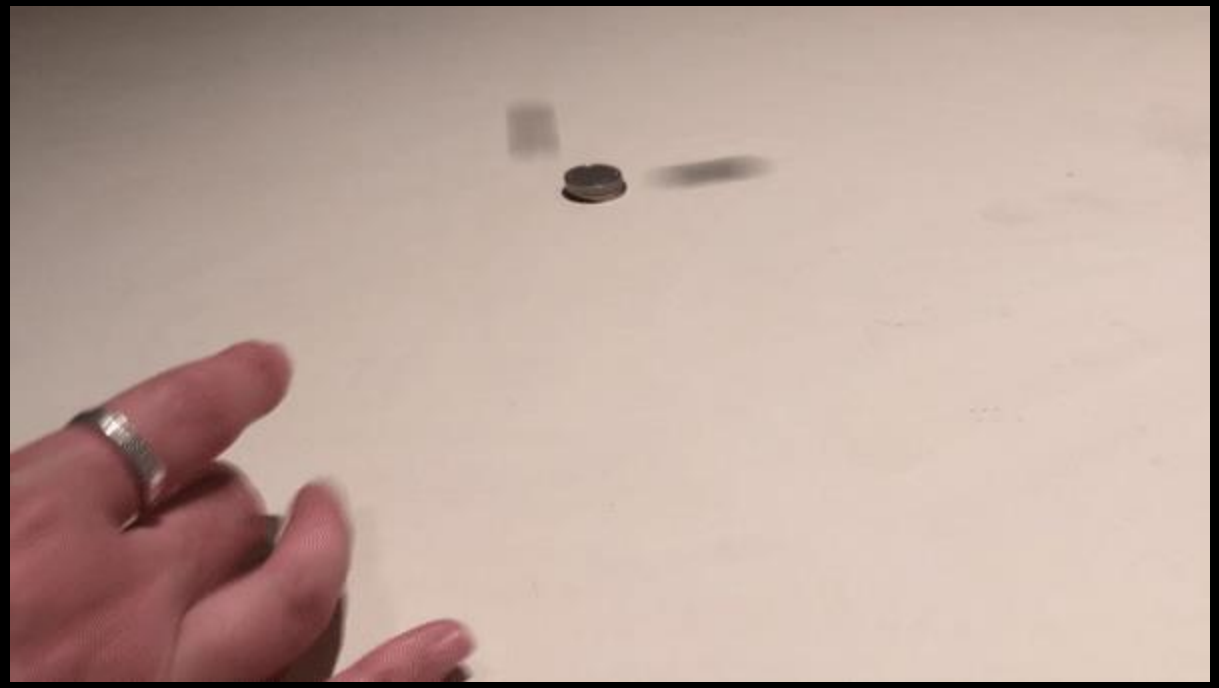
- A person standing in a bus fall backward whe suddenly.
- A person standing in a moving bus falls forwa breaks suddenly.

Inertia (First law of motion) in everyday life

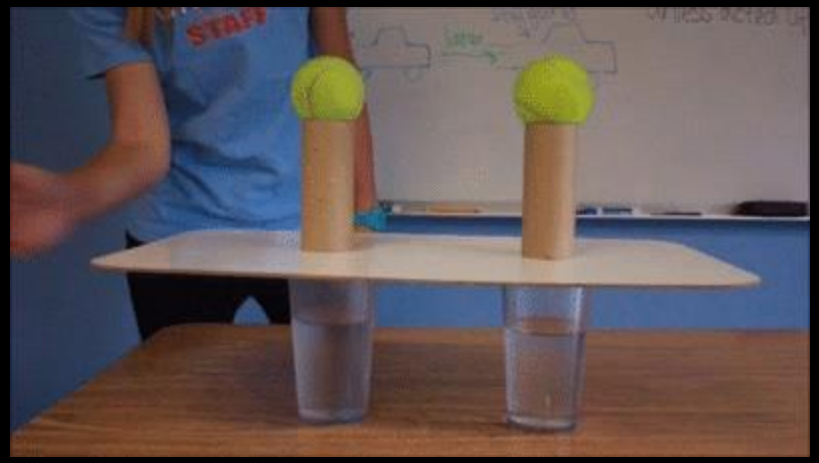
- Before hanging wet cloths over laundry line given to the clothes to get them dried quic

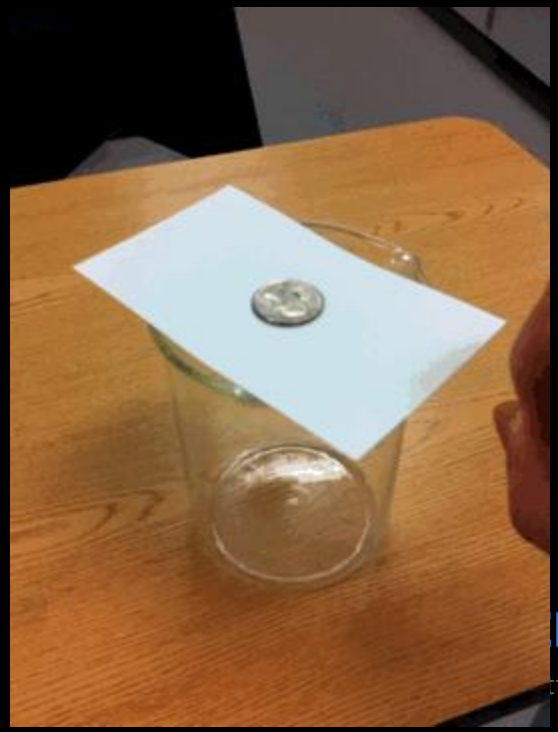
Inertia (First law of motion) in everyday life

- When pile of coins on the carrom board is hit by a striker, coin only at the bottom moves away leaving rest of the pile of coin at the same place



Inertia (First law of motion) in everyday life





Inertia (First law of motion) in everyday life

Inertia (First law of motion) in everyday life

- Falling of fruits and leaves

Inertia (First law of motion) in everyday life

- Dusting a carpet

Inertia (First law of motion) in everyday life

- Running of an athlete before taking a long ju

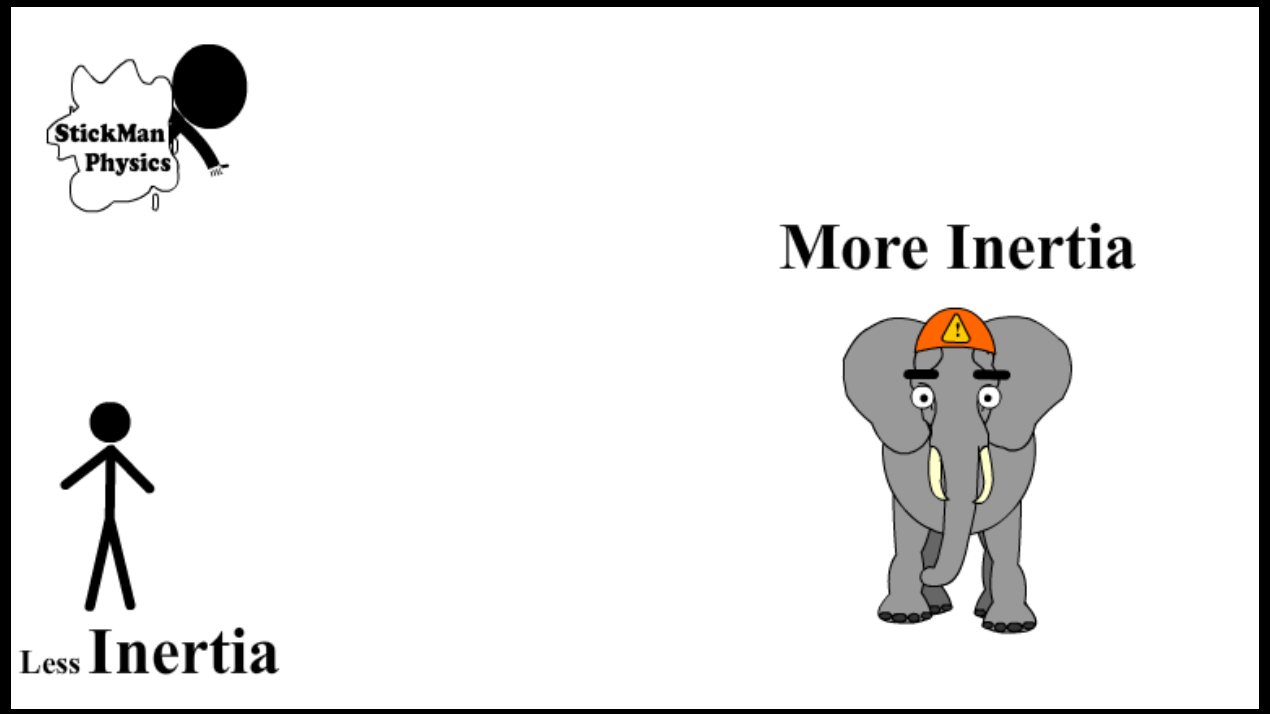
Inertia (First law of motion) in everyday life

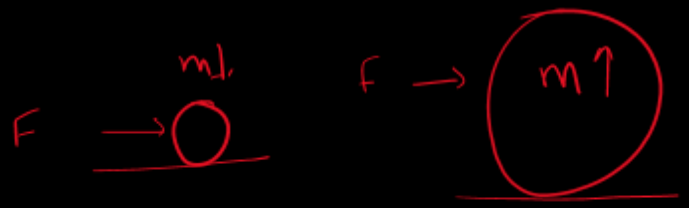
- Continued swirling of milk after the stirring is stopped.

Inertia and Mass

inertia $\propto$ mass

- Inertia is the natural tendency of an object to resist change in its state of rest or of motion.
- The inertia of an object is dependent upon its mass.
- Lighter objects have less inertia, that is, they can easily change their state of rest or motion.
- Heavier objects have large inertia and therefore they show more resistance.
- Hence 'Mass' is called a measure of the inertia of an object.





Newton's Second Law of Motion

F=ma

Quantitative explanation to calculate the amount of force ($F = ma$)