What causes Motion?

→ Motion is caused due to force

State

Rest Motion

Force can:

- Bring a rested body to Motion
- Bring a moving body to rest
- Speed up a body (acceleration)
- Speed down a body (applying brakes)
- Change the direction of a body
- Change the shape/size

→ Force is producing the change in velocity

Concept of forces

→ S.I unit of force: Newton
Represented as "N"

Case 1

10 N 10 N

Net force = 0

Balanced force

Acceleration = 0

Case 2

10 N 30 N

F_{net} = 30−20

= 10 N

Unbalanced force

→ a_c = 0 → No change in velocity

Frictional force

Contact and Non-contact forces → Types of forces

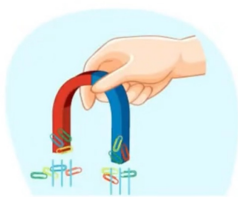
Contact Forces

Frictional force

Spring force

Muscular force

Non-Contact Forces



Magnetic Force

Gravitational Force

Electrostatic Force

Force

Conservative force

- Work done is independent of the path
- Work done is 0 in case of closed path
- Eg: gravitational force, non-contact force, spring force
  - Exception

Non-conservative force

Work done is dependent on path taken

- Eg: frictional force

Laws of motion

- By Newton and Galileo
- However three laws of motion given by Newton

1st Law of Motion

An object if at rest remains at rest or if in motion remains in motion at a constant velocity unless an external force is applied on it

Inertia
- Rest
- Motion
- Direction

Depends on mass of the object

Inertia $\propto$ Mass

Current state → Change → Inertia

Change → Resist

Examples:

- The dry leaves and fruits falls when we shake a tree
- A person sitting in a moving car may be pushed forward when the car stops abruptly as our legs are in contact with the surface

2nd Law of Motion

Momentum → Quantifies motion

S.I unit of p = Kg m/s

$p = m \times V$

M_V Truck (where mass of the body is more than the velocity)

V_m Bullet bike (where the velocity is more than the mass of the truck)

Force = rate of change in momentum

Derivation

- change in momentum = mV − mu
- Rate of change in momentum = $\frac{mV - mu}{t}$

$= m\frac{(V - u)}{t}$

a

Force (f) = ma

$F = m \times a$

F = Kg m/s²

F = vector quantity

m = scalar quantity

a = vector quantity

p = vector quantity

m = scalar quantity

V = vector quantity

A constant force acts on an object of mass 5 kg for a duration of 2 s. It increases the object's velocity from 3 m s–1 to 7 m s-1. Find the magnitude of the applied force. Now, if the force was applied for a duration of 5 s, what would be the final velocity of the object?

$F = m \times a$

$F = m \times \left(\frac{v - u}{t}\right)$

$F = 5 \times \left(\frac{7 - 3}{2}\right)$

$\frac{5 \times 4}{2} = 10\ N$

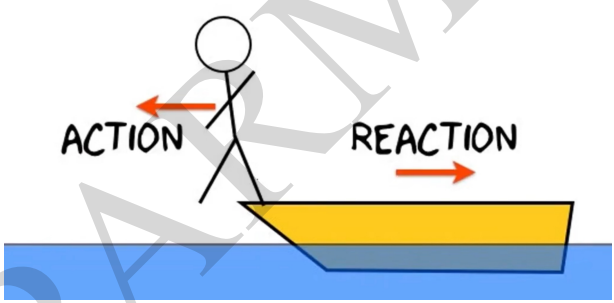
$10 = 5 \times \left(\frac{v - 3}{5}\right)$

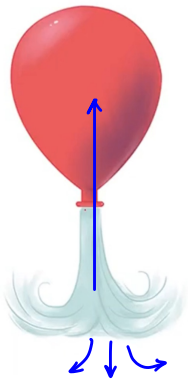
$10 = v - 3$

$V = 13\ m/s$

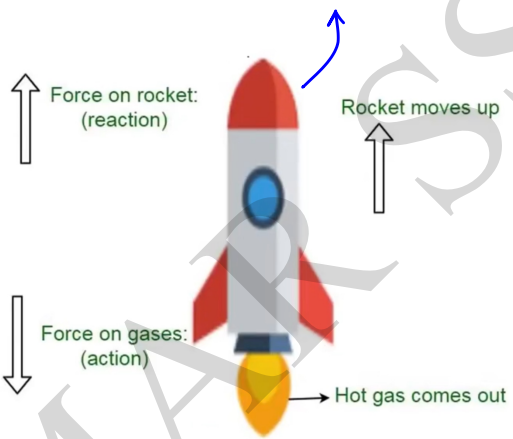
3rd Law of Motion

- It states that for every action there is an equal and opposite reaction

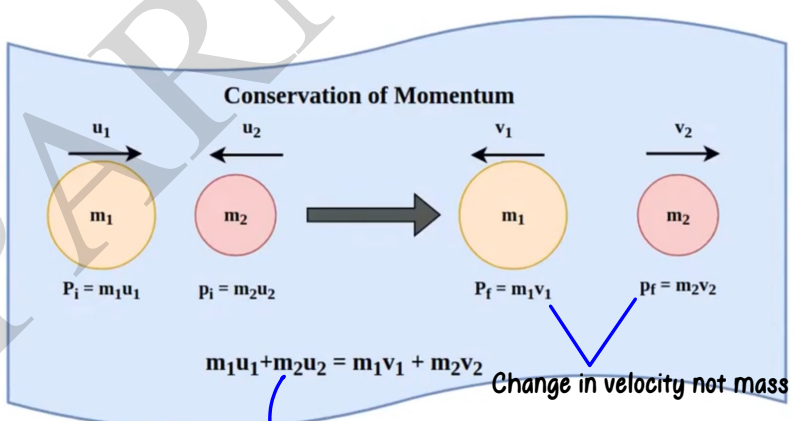




Works on conservation of momentum and Newton's 3rd law



Conservation of Momentum



Change in velocity not mass

Momentum is conserved → Conservation principle

A girl of mass 40 kg jumps with a horizontal velocity of 5 m s-1 onto a stationary cart with frictionless wheels. The mass of the cart is 3 kg. What is her velocity as the cart starts moving? ~~Assume that there is no external unbalanced force working in the horizontal direction.~~

$m_g u_1 + m_c u_2 = (M_g + M_c) \times V$

$40 \times 5 \quad 0$

$40 \times 5 = (40 + 3) \times V$

$200 = 43\ V$

$V = 4.65$

One liners (MCQs)

- The range of weak nuclear force is of the order of 10^{-16} m
- Friction depends on the smoothness of the surfaces. The force of friction always opposes the applied forces
- The force of the Earth's gravity on every kilogram is about 10 N

  $g = 9.8\ m/s^2 \sim 10\ m/s^2$

  Every kg = 1 x 10

  = 10 N
- 'Action at a distance force': Gravitational force
- Once a satellite has been launched into orbit, the only force governing its motion is the force of: Force of gravity
- In 1785, Charles Augustine Coulomb (S.I unit of Electrostatic force) used the calibrate tortion balance to measure the force between electric charges

$$F = K \frac{q_1 q_2}{4\pi \varepsilon_0}$$

K = Constant

Where q = charge

- The measure of force that can cause an object to rotate about an axis is called: Torque