Universal Law of Gravitation

m_1 ——— r ——— m_2

Both are non-contact and conservative forces

- Work done is independent of path
- Work done in a close path is zero

$F \propto \frac{M_1 M_2}{r^2}$

$F = G\frac{M_1 M_2}{r^2}$

G → Gravitational Constant

- G = Gravitational constant
- Value: $6.67 \times 10^{-11}\ Nm^2/Kg^2$
- Discovered by: Henry Cavendish (1798)

S.I unit

$F = \frac{G M_1 M_2}{r^2}$

$N = G\frac{Kg^2}{m^2} \rightarrow G = \frac{Nm^2}{Kg^2}$

Electrostatic Force

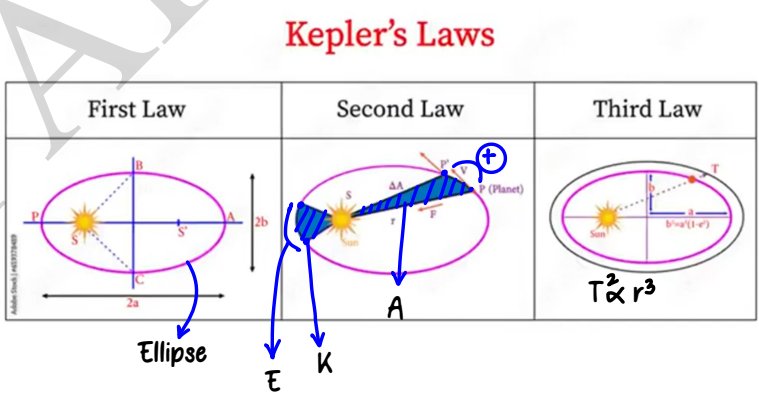
q_1 ——— r ——— q_2

$F \propto \frac{q_1 q_2}{r^2}$

$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$

- q = charge
- S.I unit of charge: Coulomb

Kepler's Planetary Laws



- **First Law: Law of Orbit**

  Planets move in elliptical orbits with the Sun as a focus

- **Second law: Law of Area**

  The line joining the planet and the Sun sweep out equal areas in equal interval of time

- **Third law: Law of Time Period**

  Cube of mean distance of a planet from the Sun is proportional to the square of the time period/orbital speed → $T^2 \propto r^3$

- Mercury nearest to Sun: 88 days revolution
- Neptune farthest to Sun: 165 yrs revolution

Difference between Mass and Weight

Inertia

Constant

- Weight: force by which Earth attracts a mass
- Force = m x a

Weight = m x g

Constant

Gravity differs

Variation in gravity

1. Gravity is more in poles than the equator
2. Gravity decreases with altitude
3. Gravity in moon is 1/6th of Earth's gravity

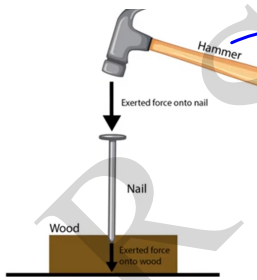
Vary ← $g = 9.8\ m/s^2 \simeq 10\ m/s^2$

Different from "G" which is constant

Thrust: when force is applied perpendicularly

- Vector quantity
- S.I Unit: Newton

Pressure: scalar quantity



Invented by Blaise Pascal

$1\ atm = 10^5$ Pascal

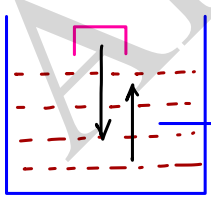
Unit of pressure

$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$$

$$P = \frac{Kgm}{s^2m^2} \qquad \frac{N}{m^2}$$

$$= Kg/ms^2 \quad \text{or} \quad N/m^2$$

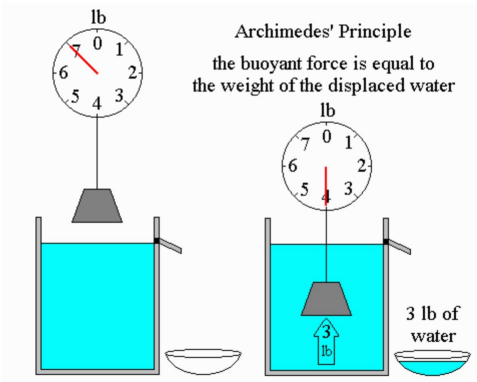
Pressure in Fluids

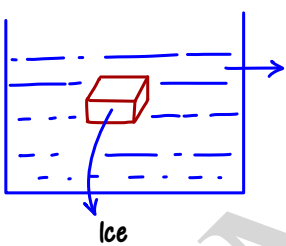


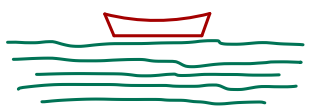
Buoyant Force

Upward force by liquid

Archimedes Principle







Relative Density

$$R.D = \frac{\text{Density of a substance}}{\text{Density of water}}$$

No unit

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

S.I unit: $\frac{Kg}{m^3}$

Work and Energy

What is work?

Force cause a displacement

S.I unit: Nm/Joule → James Prescott Joule

Work = Force x Displacement

Work = FS cos θ

Scalar quantity

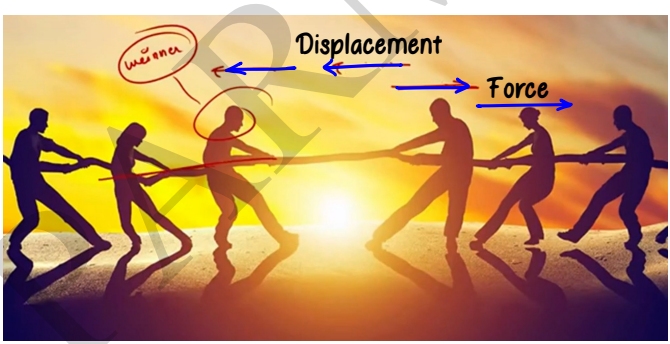
1 J = 1 N . 1 m

1 J = 2 N . $\frac{1 \text{ m}}{2}$

1 J = $\frac{1 \text{ N}}{2}$. 2 m

Work

- +ve: force and displacement have same direction → Parallel
- -ve: force and displacement are antiparallel → 180°
- 0
  - Displacement = 0
  - Angle between force and displacement is 90°



What is Energy?

Work

- **Energy**: Capacity to do work
- **S.I unit**: Joule
- Biggest source of energy: Sun

Forms of Energy

- Kinetic Energy = $\frac{1}{2} m \times V^2$
  - m: Mass
  - V^2: Velocity

The energy an object has because of its motion

$$K.E = \frac{1}{2} mV^2$$

Relation between K.E and Momentum

$$K.E = \frac{1}{2m} m^2V^2 = \frac{(mV)^2}{2m} = \frac{p^2}{2m} = K.E$$

$$\frac{p^2}{2m} = K.E$$

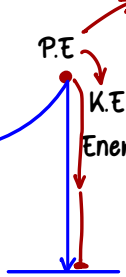
$$\frac{(2p)^2}{2m} = K.E = 4\frac{p^2}{2m}$$

Potential Energy

The energy stored in an object due to its position

Eg: Gravitational P.E

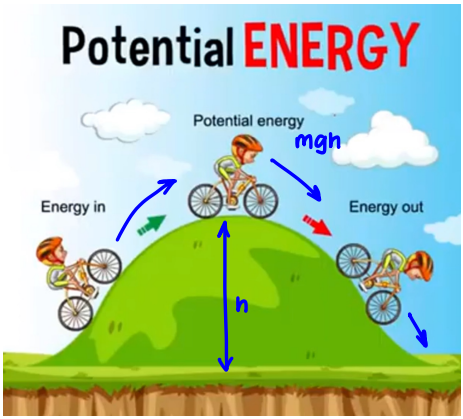
→ Concept of dams based on this →



- P.E converted to K.E
- P.E becomes less and K.E keeps increasing → Velocity max

Weight = Force = mg

Work done = Energy = F . S → mgh



Scaler

Law of Conservation of Energy

- Energy can neither be created, nor be destroyed. It can be converted from one form to another

Electrical → Heat

1. Dynamo: Mechanical energy → Electrical energy
2. Generator: Mechanical energy → Electrical energy
3. Motor: Electrical energy → Mechanical energy
4. Microphone: Sound energy → Electrical Energy
5. Loudspeaker: Electrical energy → Sound energy

Rate of doing work

$$\text{Power} = \frac{\text{Work}}{\text{Time}} \rightarrow \frac{J}{S}$$

J/S → Watt

Scalar quantity

- Rate of change of velocity = acceleration = $\frac{\Delta V}{t}$
- Rate of change of momentum = $\frac{\Delta p}{t}$

Horse Power

1 HP = 746W
1 HP = 0.746 kW

1 kW = 1000 W

Power = Force x Velocity

P = FV

Bulb

Electrical Energy → Light + Heat energy

Bulb filament made of tungsten (W)

One Liners (MCQs)

- Galileo Galilei was the 1st to conclude that in vacuum all objects fall with the same acceleration g and reach ground at same time
- An object falling freely from a height x, after fallen to a height x/2, it will possess Half potential and half kinetic energy
- The mass (Constant) of an object on the surface of the moon is 60 N, the mass on the surface of the earth will be 60 N → Weight changes not mass
- If an apple is taken to the mountain top, then it's weight is decreased
- Battery: Chemical energy → Electrical energy
- The lifting of an object up and down the parade of an army, and the free fall of a heavy object are all examples of: Rectilinear motion
- Oscillatory Motion: to and fro Motion → Follows same Path
- Periodic motion: follows same path at particular interval