Motion

Opposite of Motion: Rest

What is Motion?

- Relative change in position

  What is needed?

  → Reference point

Point of origin

Two physical quantities

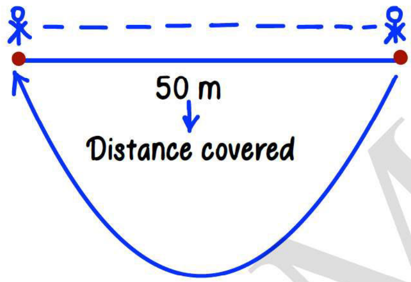
Distance

Displacement → Shortest part between two points (is a straight line)

Or

Shortest distance between initial and final point

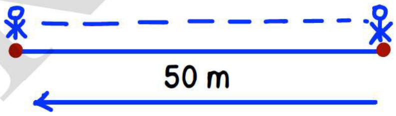
Case 1



Distance = 50 m

Displacement = 50 m

Case 2

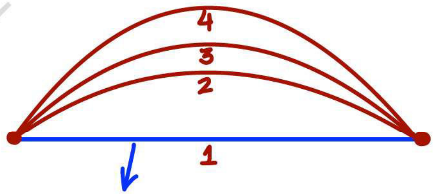


Distance = 100 m

Displacement = 0

→ Displacement: vector quantity

→ Distance: scalar quantity

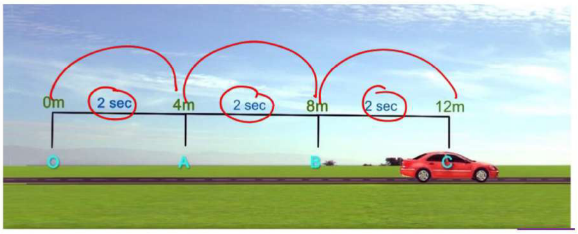


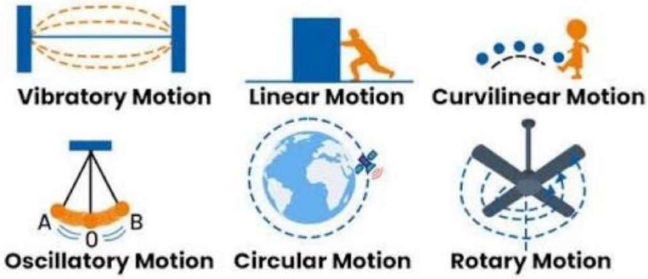
Case 1: shortest distance

Displacement

Types of Motion

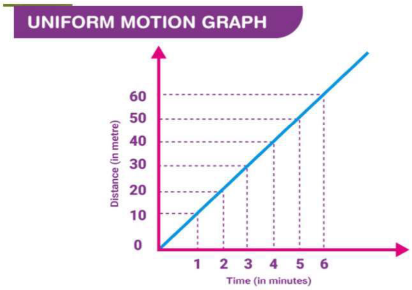
Very Lazy Cats Often Chase Rats

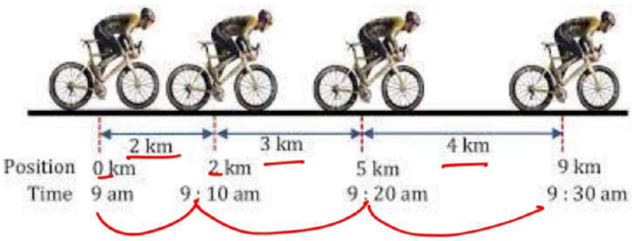




Uniform Motion

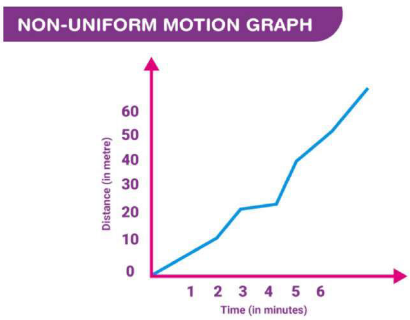
- Equal distance covered in equal intervals





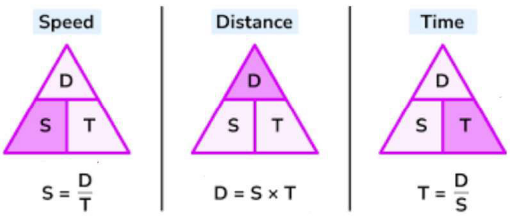
Non-Uniform Motion

- Equal distance in unequal intervals



Speed

- Rate of change of motion Called as Speed (time is involved)



S.I. Unit of Speed : m/s

- International System of Units: 1960

When motion is non-uniform

$$\text{Average Speed} = \frac{\text{Total Distance Covered}}{\text{Total Time Taken}}$$

Q. An object travels 16 m in 4 sec and then another 16 m in 2 sec. What is the Average Speed of the object?

Sol: $\text{Average speed} = \frac{\text{Total Distance}}{\text{Total Time}} = \frac{16 + 16}{4 + 2}$

$= \frac{32}{6} = 5.33 \text{ m/s}$

Remember

$$1 \text{ km/hr} = \frac{5}{18} \text{ m/s}$$

$$1 \text{ m/s} = \frac{18}{5} \text{ km/h}$$

Speed + Direction = Velocity

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

Unit: m/s

$v = d / t$
$t = d / v$
$d = v \cdot t$

- Odometer: It is used to measure the distance travelled by a vehicle

Scalar quantity	Vector quantity
Only represents numerical value	Numerical value + Direction
Distance	Displacement
Speed	Velocity
Time	

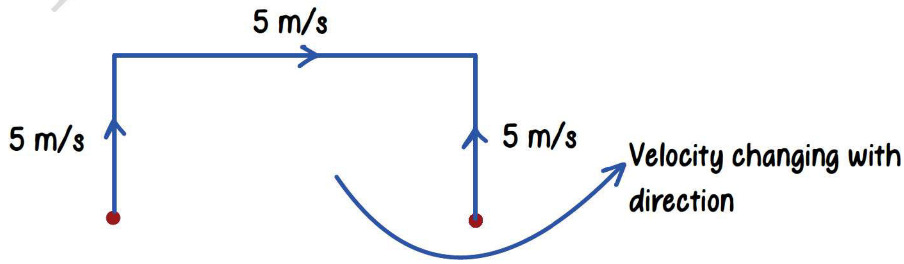
Usha swims in a 90 m long pool. She covers 180 m in one minute by swimming from one end to the other and back along the same straight path. Find the average speed and average velocity of Usha.

उषा 90 मीटर लंबी नाव में तैरती है
पूल। वह एक मिनट में 180 मीटर की दूरी तय करती
हैं एक छोर से दूसरे छोर तक तैरकर
और उसी सीधे रास्ते पर वापस।
औसत गति और औसत ज्ञात कीजिए
उषा का वेग.

→ $\text{Avg. speed} = \frac{180}{60} = 3 \text{ m/s}$

$\text{Avg. velocity} = \frac{0}{60} = 0 \text{ m/s}$

Rate of change in velocity → Is called Acceleration



Change in velocity = Final speed – Initial speed

Acceleration = $\frac{m/s}{s}$ = m/s² → a_c

$a_c = \frac{\text{change in velocity}}{\Delta t} = \frac{\text{Final velocity} - \text{Initial velocity}}{\Delta t} = \frac{V - u}{\Delta t}$

Starting from a stationary position, Rahul paddles his bicycle to attain a velocity of 6 m s–1 in 30 s. Then he applies brakes such that the velocity of the bicycle comes down to 4 m s-1 in the next 5 s. Calculate the acceleration of the bicycle in both the cases.

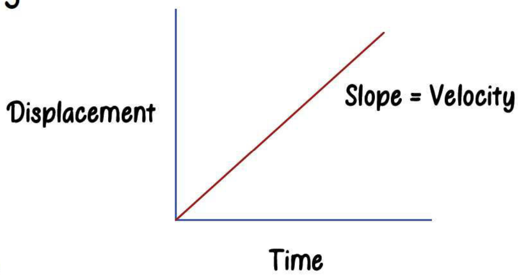
→

Case 1

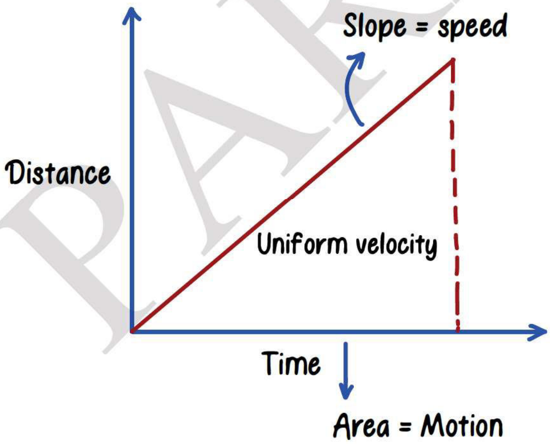
Initial speed = 0
Final speed = 6 m/s] 30 s ⟶ $a_c = \frac{6-0}{30} = \frac{1}{5} = 0.2\ m/s^2$

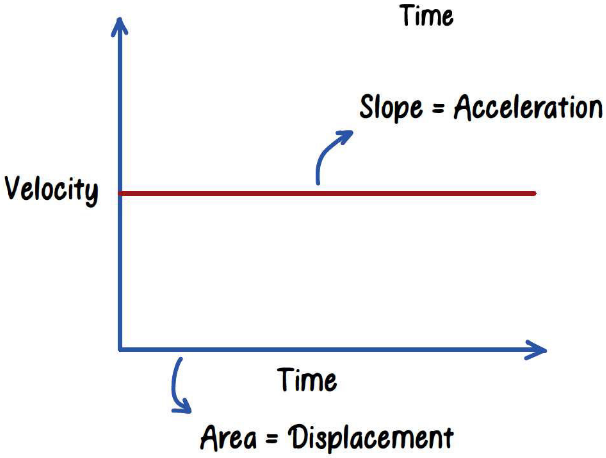
Case 2

Initial speed = 6 m/s
Final speed = 4 m/s] 5 s $a_c = \frac{4-6}{5} = \frac{-2}{5} = -0.4\ m/s^2$



Graph Representation





Numerical of Motion in straight line: The 'UTSAV' Concept

u = 0

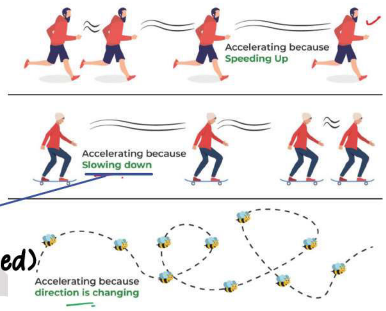
Stationary free fall starting from rest

3 equations of motions

Horizontal motion

- 1 $v = u + at$
- 2 $s = ut + \frac{1}{2}at^2$
- 3 $v^2 - u^2 = 2as$

- u = initial velocity
- t = time
- s = distance
- a = acceleration
- v = final velocity



Deceleration
(reduction in speed)

Straight line motion → Rectilinear motion

Vertical

Horizontal

Vertical motion

a = g → Acceleration due to gravity

Free fall → u = 0

Initial speed

- $v = u + gt$
- $h = ut + \frac{1}{2}gt^2$
- $v^2 - u^2 = 2gh$

Against the gravity

(a = −g)

final velocity v = 0

- $v = u - gt$
- $h = ut - \frac{1}{2}gt^2$
- $v^2 - u^2 = -2gh$

A train starting from rest attains a velocity of 72 km/h in 5 minutes. Assuming that the acceleration is uniform, find (i) the acceleration and (ii) the distance travelled by the train for attaining this velocity

एक ट्रेन विश्राम से प्रारंभ होकर 5 मिनट में 72 किमी/घंटा का वेग प्राप्त कर लेती है। यह मानते हुए कि त्वरण एक समान है, (i) त्वरण और (ii) इस वेग को प्राप्त करने के लिए ट्रेन द्वारा तय की गई दूरी ज्ञात कीजिए।

→ $u = 0$, $v = 72$ km/hr, 5 min → $5 \times 60 = 300$ s

$72 \times \frac{5}{18} = 20$ m/s

$a_c = \frac{20-0}{300} = \frac{20}{300} = \frac{1}{15}$ m/s

$s = ut + \frac{1}{2}at^2$

$s = 0 + \frac{1}{2} \times \frac{1}{15} \times (300)^2$

$= 3000$ m

$s = 3$ km

A car accelerates uniformly from 18 km/h to 36 km/h in 5 s. Calculate (i) the acceleration and (ii) the distance covered by the car in that time.

एक कार समान रूप से गति करती है , 5 सेकंड में 18 किमी/घंटा से 36 किमी घंटा-1 तक।
(i) त्वरण और (ii) की गणना करें
इतने समय में कार द्वारा तय की गई दूरी।

→ $u = 18 \text{ km/h} \times \frac{5}{18}$

$= 5$ m/s

$v = 36 \times \frac{5}{18} = 10$ m/s

$a = \frac{10-5}{5} = \frac{5}{5} = 1$ m/s

$s = ut + at^2$

$= 5(5) + \frac{1}{2} \times (5)^2$

$= 37.5$ m

Uniform Circular Motion → motion of a body moving with speed along the circular path

Uniform = speed (Constant)

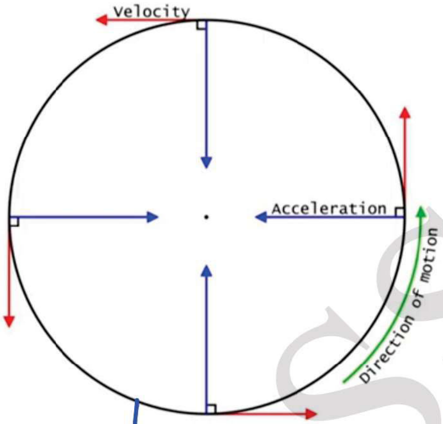
$a_c = \frac{v^2}{r}$

Centripetal acceleration

Acceleration towards the centre in circular path

$F = m \times a$

$= \frac{m \times v^2}{r}$

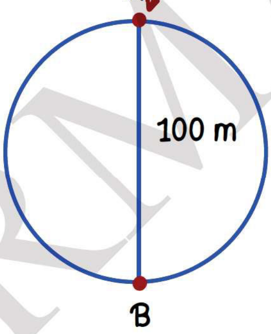


Change in velocity at every point

An athlete completes one round of a circular track of diameter 100 m in 20 s. What will be the displacements after 1 minute and 10 s, respectively ?

→

Displacement = 0



Displacement

= 10 s = 100 m

1 min = 60 sec

Force & Laws of Motion

What causes Motion?

→ Motion is caused due to force

State

- Rest
- Motion

Balanced Forces

- These forces cancel each other out.
- The $F_{Net} = 0$

Unbalanced Forces

- These are forces that do not cancel each other out.
- F_{Net} is not equal to zero.

Force can:

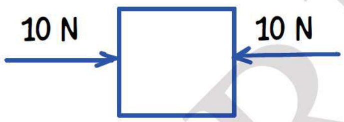
- Bring a rested body to Motion
- Bring a moving body to rest
- Speed up a body (acceleration)
- Speed down a body (applying brakes)
- Change the direction of a body
- Change the shape/size

→ Force is producing the change in velocity

Concept of forces

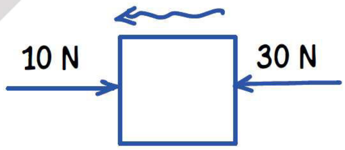
→ S.I unit of force: Newton
Represented as "N"
Unit: $kg\ m/s^2$

Case 1



Net force = 0
↓
Balanced force
Acceleration = 0

Case 2

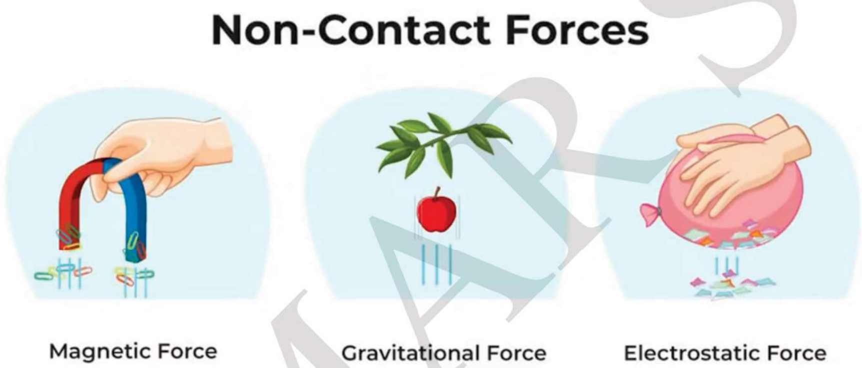


$F_{net} = 30-20$
$= 10$ N
↓
Unbalanced force

→ $a_c = 0$ → No change in velocity

Frictional force

Contact and Non-contact forces → Types of forces



Force

- Friction drag is a force that resists the motion of an object moving through a fluid.

(Depends on final and initial point)

Conservative force

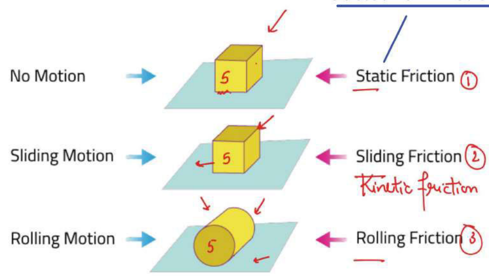
- Work done is independent of the path
- Work done is 0 in case of closed path
- Eg: gravitational force, non-contact force, spring force → Exception

Non-conservative force

Work done is dependent on path taken

- Eg: frictional force

Order of Force: 1 > 2 > 3



Laws of motion

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

By observing the motion of objects on an inclined plane Galileo deduced that objects move with a constant speed when no force acts on them.

- Galileo published a series of essays named: De Motu
- Galileo's first book: La Bilancetta (the little balance) published in 1586

1st Law of Motion

Also known as Law of Inertia

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

Current state → Change → Resist

Change → Inertia

Inertia → Depends on mass of the object

$\boxed{\text{Inertia} \propto \text{Mass}}$

Types of Inertia

- Inertia of rest
- Inertia of motion
- Inertia of direction

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

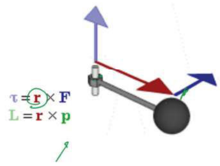
$\boxed{p = m \times V}$

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)

p = vector quantity
m = scalar quantity
V = vector quantity

- Torque: It is the measure of the force that can cause an object to rotate about an axis. It is a rotational force



Force = rate of change in momentum

$F = m \times a$

$F = Kg\ m/s^2$

F = vector quantity
m = scalar quantity
a = vector quantity

Derivation

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

$= m\frac{(V-u)}{t}$ → a

Force (f) = ma

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?

$$F = m \times a$$
$$F = m \times \left(\frac{v-u}{t}\right)$$
$$F = 5 \times \left(\frac{7-3}{2}\right)$$
$$F = 5 \times \frac{4}{2} = 10\ N$$

$$10 = 5 \times \left(\frac{v-3}{5}\right)$$
$$10 = v - 3$$
$$V = 13\ m/s$$

Impulse and Momentum

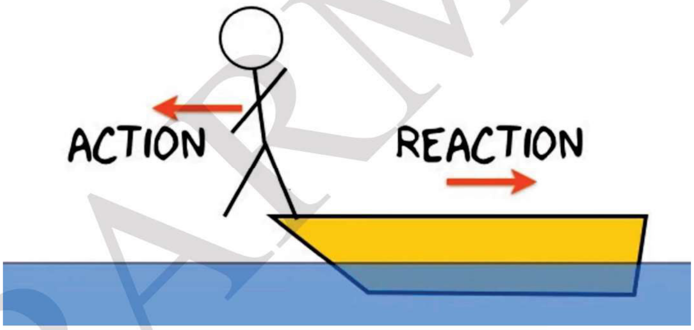
- Impulse: It is the force applied for a very short duration.
- Momentum: It is quantity that measures how much motion an object has.

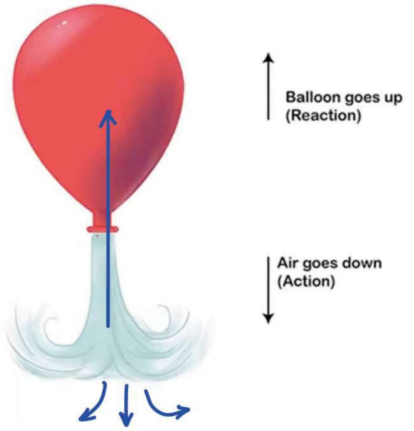
$$F \triangle t = m \triangle V$$

Action-Reaction Law

3rd Law of Motion

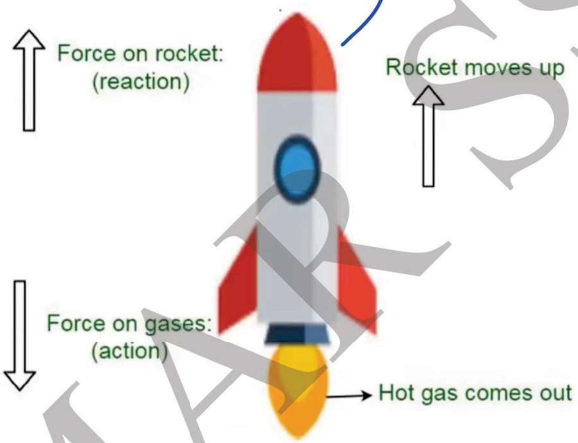
- It states that for every action there is an equal and opposite reaction



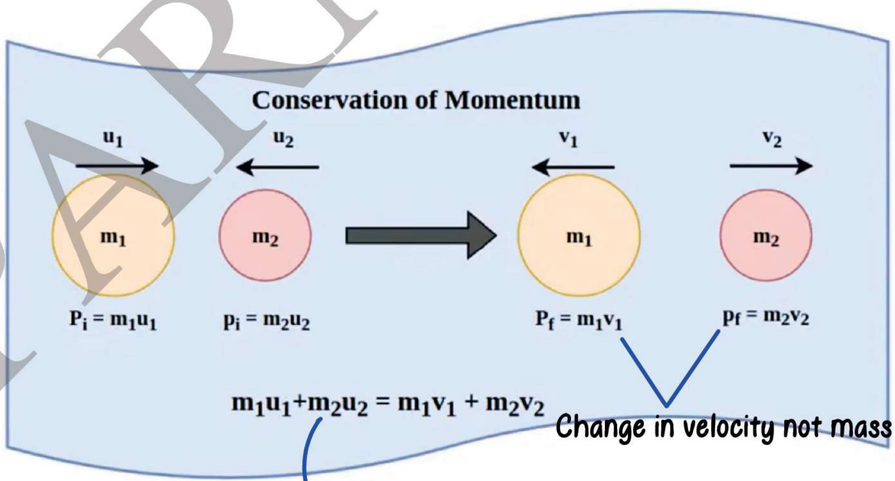


Gas expelled out

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.~~

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

$$40 \times 5 + 3 \times 0 = 40 \times V + 3 \times V$$

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

$$200 = 43\ V$$

$$V = 4.65$$

Gravitation / Work done

Universal Law of Gravitation

Moon gravity is 1/6 of Earth's gravity
weight = mass * gravity

m_1 — r — m_2

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

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

Gravitational Constant

Both are non-contact and conservative forces

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

Electrostatic Force

q_1 — r — q_2

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

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

If F > 0 -> Repulsion: occurs whe both charges (q_1, q_2) are of the same sign (+/+ or −/−)
If F < 0 -> Attraction: occurs whe charges are opposite (+/−)

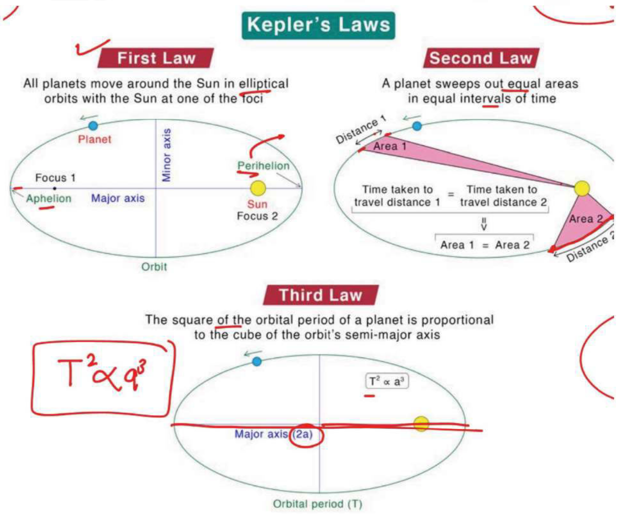
- q = charge
- S.I unit of charge: Coulomb

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

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

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

Kepler's Planetary Laws (Given in 1609)



→ **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 → $T^2 \propto r^3$

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

Difference between Mass and Weight

Mass → Inertia

Mass → Constant

- Weight: force by which Earth attracts a mass

→ Force = m x a

$\boxed{\text{Weight} = m \times g}$

m → Constant

g → Gravity differs

Mass	Weight
The mass of a body is amount of matter present in it	The weight of a body is the force with which the earth attracts it
It has magnitude but not direction (scalar quantity)	It has both magnitude and direction (vector quantity)
It does not change from place to place	It changes from place to place (W = m x g)
It can never be zero	It is zero at the center of earth
Its S.I. Unit is kilogrm	Its S.I. Unit is Newton

Variation in gravity

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

$$F = \frac{GMm}{R^2}$$

$$m \times g = \frac{GMm}{R^2}$$

$$g = G\frac{M}{R^2}$$

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

M = mass of Earth

R = radius of Earth

Constant uniform acceleration

$\boxed{\text{Vary}}$ ← $g = 9.8\ m/s^2 \approx 10\ m/s^2$

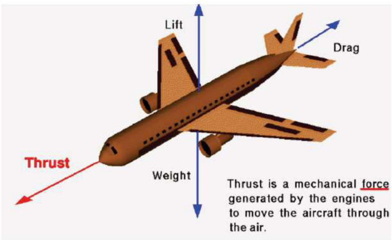
→ Different from "G" which is constant

- Gravity would decrease on going to a certain height and as well as going to a certain depth.
- Gravity is influenced by the distribution of mass of material within the earth

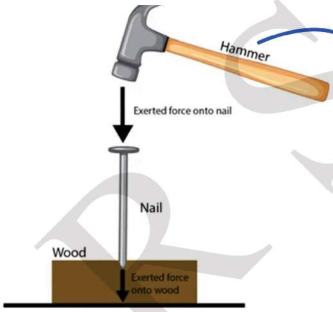
Thrust: when force is applied perpendicularly

→ Vector quantity

S.I Unit: Newton



Pressure: scalar quantity



Invented by Blaise Pascal

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

1 atm = 1.013×10^5 pascal

1 atm = 1.013 bars

1 Newton = 10^5 Dyne

C.G.S unit

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

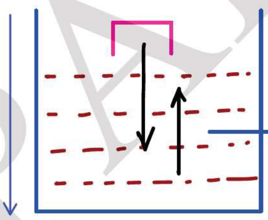
$$= Kg/ms^2 \quad \text{or} \quad N/m^2$$

Pascal's Law

- Pascal's law (also Pascal's principle or the principle of transmission of fluid-pressure) is a principle given by Blaise Pascal that states that a pressure change at any point in a confined incompressible fluid is transmitted throughout the fluid such that the same change occurs everywhere.
- Given in 1653 and published in 1663.

Pressure in Fluids

Increased depth

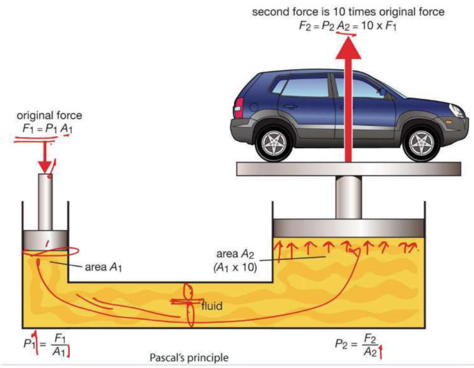


Pressure increase

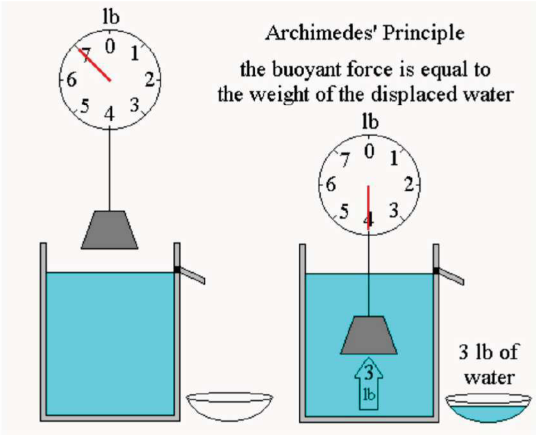
→ Buoyant Force

↓

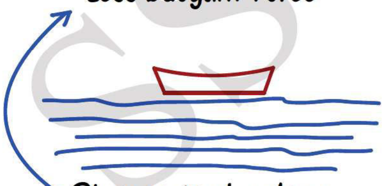
Upward force by liquid



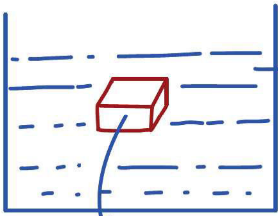
Archimedes Principle (It was given around 250 BC)



Less buoyant force

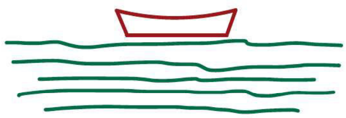


River water has less density → No salt content



→ Same water level

Ice



Sea water has high density → High salt content

High buoyant force

Relative Density

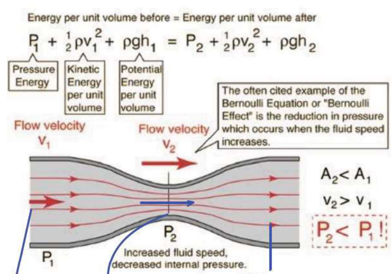
$$R.D = \frac{\text{Density of a substance}}{\text{Density of water}}$$

No unit

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

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

Bernoullis Principle



Higher pressure, lower speed

Lower pressure, Higher speed

Higher pressure, Lower speed

- Pressure energy + Kinetic energy + Potential energy = Constant

$= \Delta KE = 1/2 * m * (v^2 - u^2)$

work done = change in kinetic energy

Work and Energy

What is work?

Force cause a displacement

S.I unit: Nm → James Prescott Joule

Joule

Work = Force x Displacement

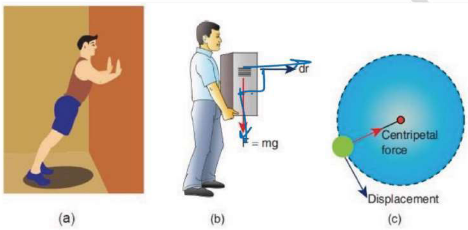
$\boxed{\text{Work} = FS\cos\theta}$

Scalar quantity

Substance	Density, g/mL
Hydrogen (gas)	0.000089
Carbon dioxide (gas)	0.0019
Cork	0.21
Oak wood	0.71
Ethyl alcohol	0.79
Water	1.00
Magnesium	1.74
Table salt	2.16
Sand	2.32
Aluminum	2.70
Iron	7.86
Copper	8.92
Lead	11.34
Mercury	13.59
Gold	19.3

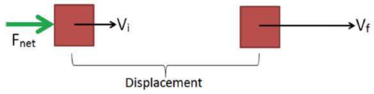
Silver = 10.8

Work –
- **+ve:** force and displacement have same direction (displacement is along the direction of force) → Parallel
- **–ve:** force and displacement are antiparallel (displacement is opposite the direction of force) → 180°
- **0** → Displacement = 0
  → Angle between force and displacement is 90°

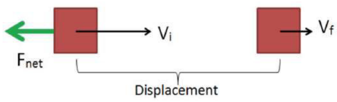


Zero Work Done

Positive Work



Negative Work



What is Energy?

Work

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

Forms of Energy

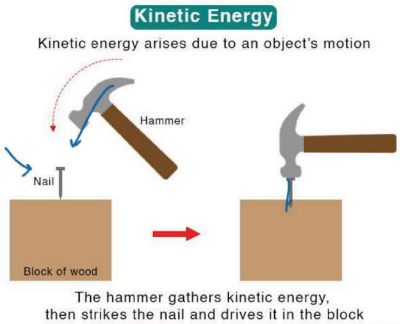
- Kinetic Energy = $\frac{1}{2}$ m x V^2

Mass

Velocity

The energy an object has because of its motion

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



Relation between K.E and Momentum

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

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

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

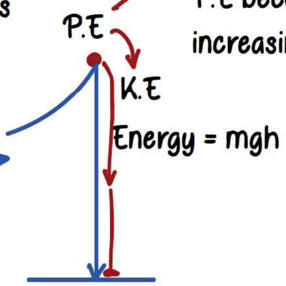
If the momentum of a body is doubled, the kinetic energy becomes 4 times.

Potential Energy

The energy stored in an object due to its position

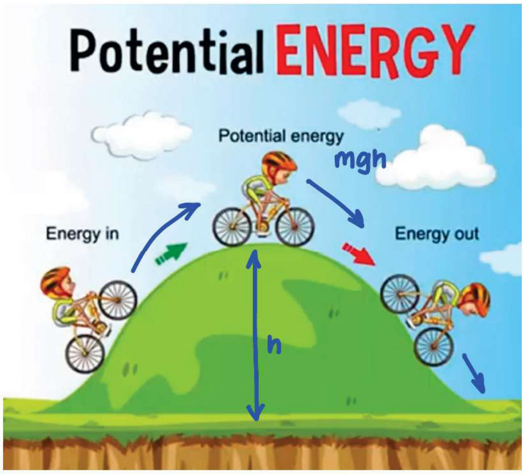
Eg: Gravitational P.E

→ Concept of dams based on this



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

$$\boxed{\begin{array}{l} \text{Weight} = \text{Force} = mg \\ \text{Work done} = \text{Energy} = F \cdot S \\ \qquad\qquad\qquad\qquad \downarrow \\ \qquad\qquad\qquad\qquad mgh \end{array}}$$



Escape Velocity:

- The velocity needed for a body to escape from a gravitational centre of attraction without undergoing any further acceleration.
- E.g. imagine throwing a ball upwards: if you throw it lightly, it comes back down due to gravity; however, if you throw it with a high enough velocity, it will escape Earth's gravity and never return
- Escape velocity is approx. 11.2 km/s
- Velocity = 0; K.E. = 0, and P.E. = Max (when reached at a certain height)
- P.E. = 0; K.E. = Max escape (when the ball returns back)
- K.E. = P.E. (When at centre point)

Law of Conservation of Energy → Scalar

- Energy can neither be created, nor be destroyed. It can be converted from one form to another (1st Law of Thermodynamics based on this concept)

1. Dynamo: Mechanical energy → Electrical energy
2. Generator: Mechanical energy → Electrical energy
3. Motor: Electrical energy → Mechanical energy = P.E. + K.E.
4. Microphone: Sound energy → Electrical Energy
5. Loudspeaker: Electrical energy → Sound energy

- Photosynthesis = Light energy getting converted into Chemical energy
- Battery = Chemical energy getting converted into Electrical energy

Rate of doing work

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

Scalar quantity

$\boxed{J/S \rightarrow \text{Watt}}$

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

Latent heat of vaporization -> The amount of heat required to convert 1 kg of liquid into vapour at constant temperature.
Latent heat of fission -> The amount of heat required to convert 1 kg of liquid into solid at constant temperature.

Horse Power

1 HP = 746W

1 kW = 1000 W

1 HP = 0.746 kW

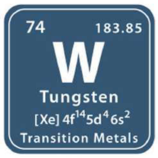
Power = Force x Velocity

P = FV

Bulb

Electrical Energy → Light + Heat energy

Bulb filament made of tungsten (W)



Melting Point : 3422°C

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

- Constant
  The mass 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

  Rectilinear motion is the motion of an object along a straight line.

- Oscillatory Motion: to and fro Motion → Follows same Path

- Periodic motion: follows same path at particular interval

Sound

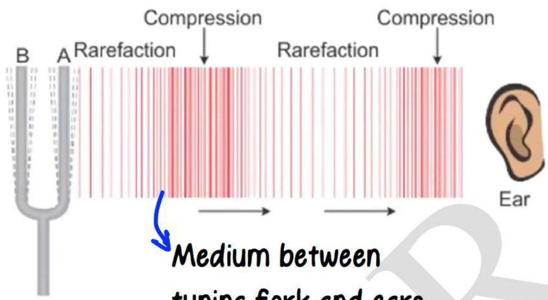
Sound: it is a form of energy

How is sound produced?

By vibrating objects

Example: vocal chords → Vibrate → Produced sound

How sound propagates?



Medium between tuning fork and ears

Types of waves

Sound energy travels in the form of energy

Waves

Mechanical wave

Medium is required to propagate

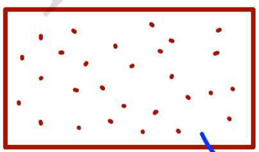
Ex: Sound waves

longitudinal waves

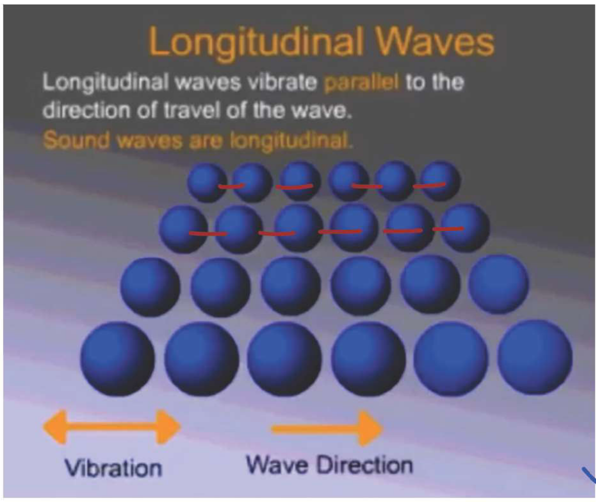
Non-mechanical wave

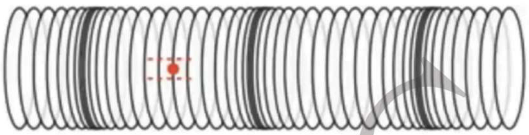
No medium is required to propagate

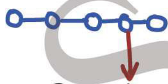
Ex: Light waves



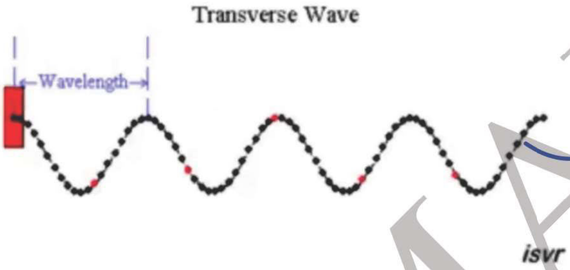
The particles in the medium helps the sound to propagate





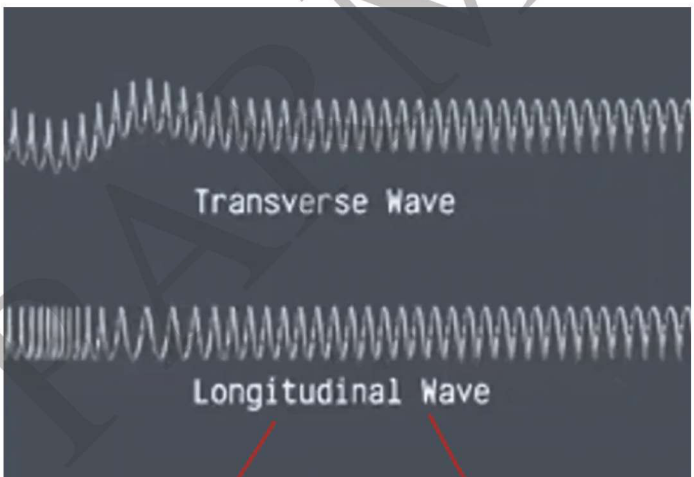


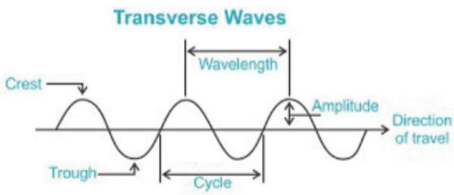
Particles do not move



- Longitudinal waves are waves where the particles of the medium vibrate parallel to the direction the wave travels, like sound waves or pressure waves.

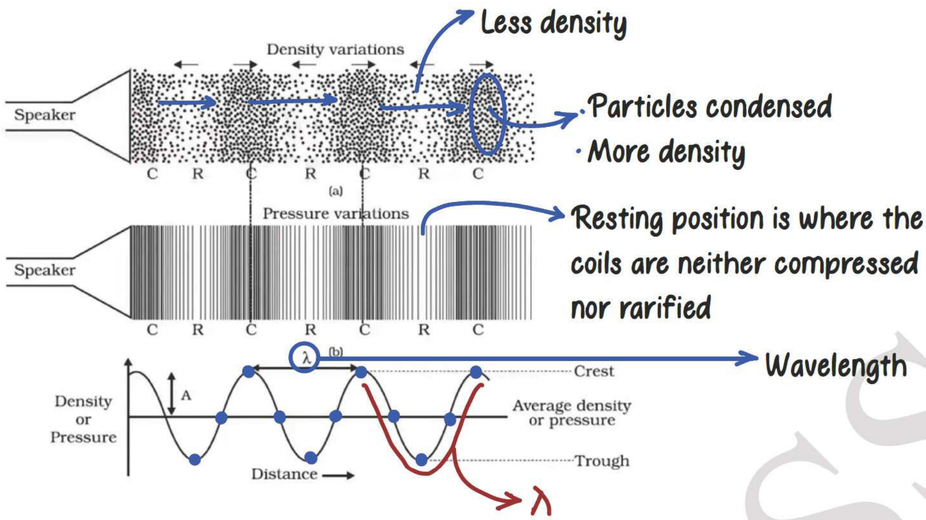
- Transverse waves are waves that moves perpendicularly to the direction of its propagation. This means that the wave forms a right angle with the direction it travels.
  They can travel though vacuum





Compression
- Particles together
- Density ↑
- Pressure ↑

Rarefaction
- Particles far away



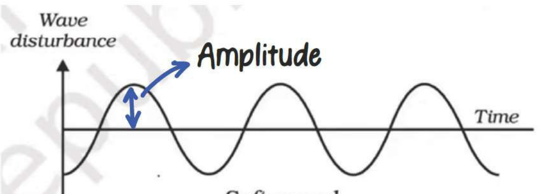
Characteristics of sound waves

Frequency (ν)$\downarrow = \dfrac{1}{\text{Time}\uparrow}$ → Unit: s^{-1}; Hertz

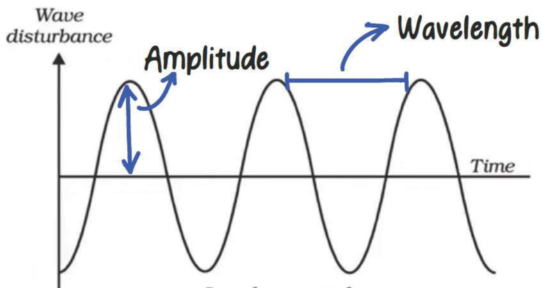
- Determines pitch of a sound
- Girls have high pitch, high shrillness → Vocal cords vibrates quickly

Amplitude: determines Loudness → Unit: dB (decibel) — Limit: 0–130 dB (sound above this is considered as noise)

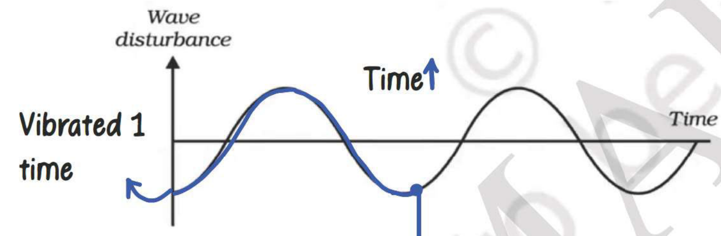
→ Can be defined as the loudness of the amount of maximum displacement of vibrating particles of the medium from their mean position when the sound is produced



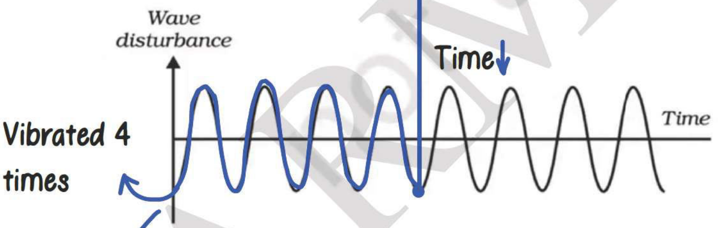
Soft sound



Louder sound



Wave shape for a low pitched sound



Wave shape for a high pitched sound

Wave taking less time to vibrate

- Timber: quality of sound
- Note: sound, which is a mixture of several frequencies

Mosquito: frequency↑ Pitch↑
Lion: amplitude↑ Loudness↑

Audible range: 20 Hz–20,000 Hz

- Human Ear : 20 Hz–20,000 Hz
- Less than 20 Hz : Infrasonic
- More than 20,000 Hz : Ultrasonic

$$\text{Mach no} = \frac{\text{Speed of any body}}{\text{Speed of sound in that medium}}$$

- **Subsonic:** Mach < 1
- **Supersonic:** >1 ; ≤ 5
- **Hypersonic:** Mach > 5
- **Transonic:** Mach = 0.8–1.2

- Animals can hear infrasonic sounds

Speed of sound

- Solid > Liquid > Gas
- Light = 3×10^8 m/s

Speed of light is more than the speed of the sound

CREST

Speed of Sound in Different Media at 25 °C

State	Substance	Speed in m/s
Solids	Aluminium	6420
	Nickel	6040
	Steel	5960
	Iron	5950
	Brass	4700
	Glass (Flint)	3980
Liquids	Water (Sea)	1531
	Water (Distilled)	1498
	Ethanol	1207
	Methanol	1103
Gases	Hydrogen	1284
	Helium	965
	* Air	346
	Oxygen	316
	Sulphur dioxide	213

Reflection of Sound

Sounds reflection: Echo

It is a reflection of sound that arrives at the listener with the delay after the direct sound

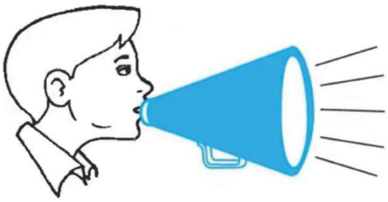
Distinct reflection

Source —— Reflect

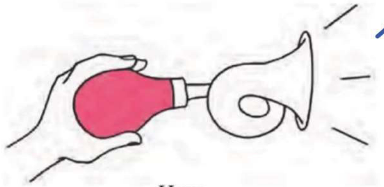
Distant: 17.2 m

Distinct reflection

Echo: A single reflection of sound.
Reverberation: Multiple reflections of sound that overlap.

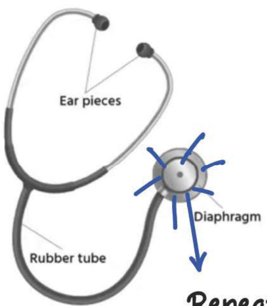


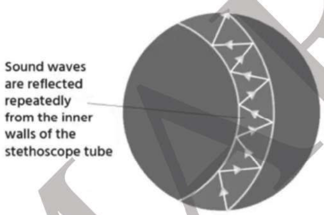
Megaphone



Horn

Reverberation: repeated reflection of sound





Repeated sound reflection

Penetrating power is very high

Applications of Ultrasonic sounds

- Produced by bats, dolphins
- Ultrasound is banned in gender determination
- To monitor growth and development of fetus
- Used to identify kidney stones and to break kidney stones
- To identify the conditions of our internal organs

SONAR: Sound Navigation and Ranging

Device that is used for detecting and locating objects specially underwater by the means of sound waves sent out to be reflected by the objects

Reflection & Refraction

What is light? → It is a form of energy

- It has dual nature → Particle and as a form of wave (Duality of light)
- Light is a form of transverse wave
- It can travel in vacuum
- It can be polarised

Theories: Young Double Slit Experiment
This experiment demonstrated the wave nature of light.

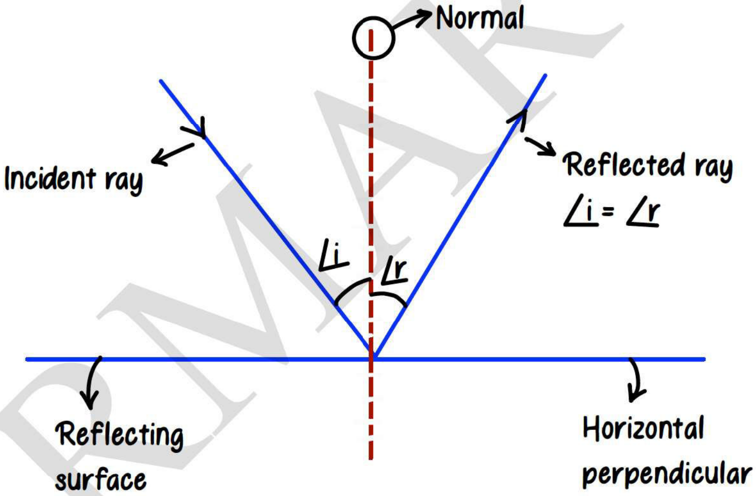
Reflection of Light

- When a ray of light approaches a smooth polish surface, and the light ray bounces back

- Photoelectric Effect: Observed first by Heinrich Rudolf Hertz in 1887

Laws of Reflection

1. The angle of incidence = The angle of reflection
2. Incident ray, reflected ray and normal ray → all lie in the same plane

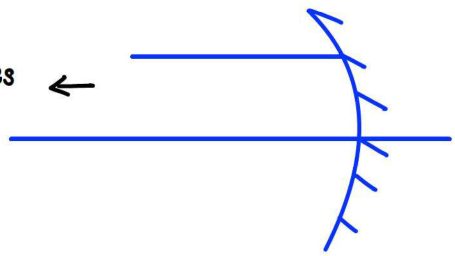


Types of Mirror

- Plane Mirror
- Spherical Mirror → Convex Mirror
  → Concave Mirror

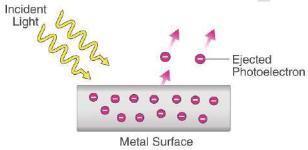
Concave Mirror

Reflecting surfaces curved inwards ←

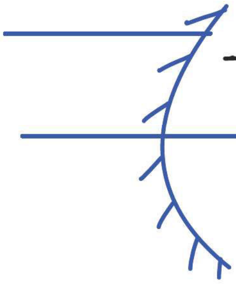


Shows the particle nature of light

- In 1905, Albert Einstein proposed that light, and thus electromagnetic radiation, consists of discrete packets of energy, which we now call photons, to explain the photoelectric effect and other light-related phenomena. (1921, received Nobel Prize)



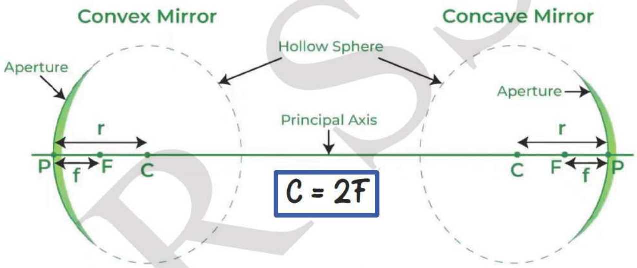
Convex Mirror



→ Reflecting surface is curved outwards

Concave Mirror

Convex Mirror

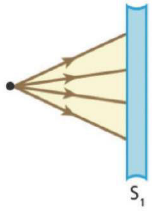


Here, F = Focal Point ; C = Center of Curvature ;
f = Focal Length ; r = Radius of Curvature ;
P = Pole

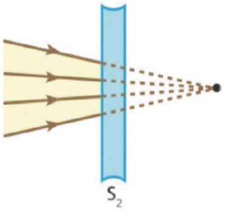
Types of Image

Located on the same side of the mirror

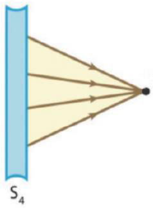
Real Image	Virtual Image
• It can be obtained on screen	• It cannot be obtained on screen
• It is inverted	• It is erect



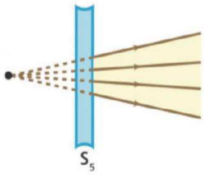
Real object



Virtual object

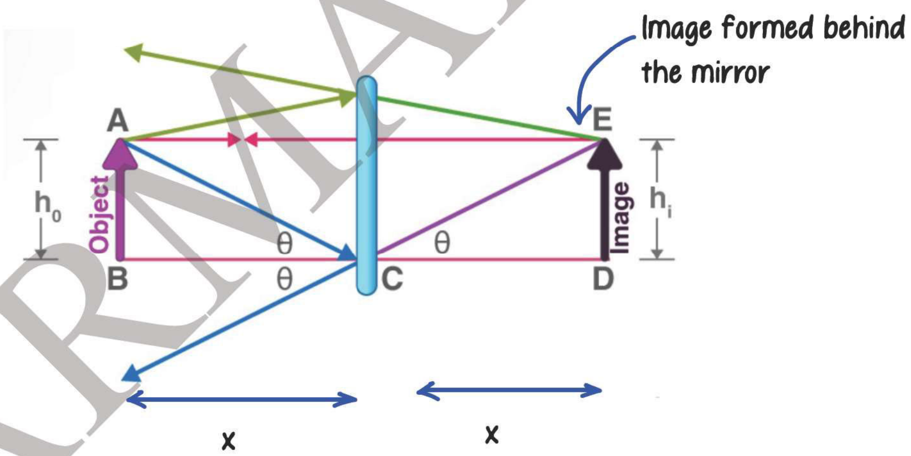


Real image



Virtual image

Image Formation



Plane Mirror

1. Image distance = Object distance
2. Object size = Image size
3. Erect → Virtual
4. Laterally inverted: Left → Right
   Right → Left

Location, size and nature of image formed by Spherical Mirrors

Concave Mirror

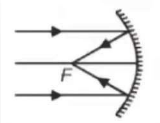
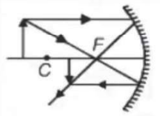
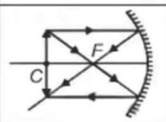
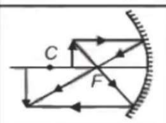
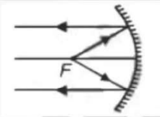
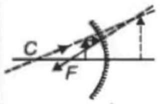
Position of object	Figure	Position of image	Nature of image
1. At infinity		At the principal focus or in the focal plane	Real, inverted, extremely diminished in size
2. Beyond the centre of curvature		Between the principal focus and centre of curvature	Real, inverted and diminished
3. At the centre of curvature		At the centre of curvature	Real, inverted and equal to object
4. Between focus and centre of curvature		Beyond centre of curvature	Real, inverted and bigger than object.
5. At the principal focus		At infinity	Extremely magnified
* 6. Between the pole and principal focus		Behind the mirror	Virtual, erect and magnified

Image Fromation of Concave Mirror

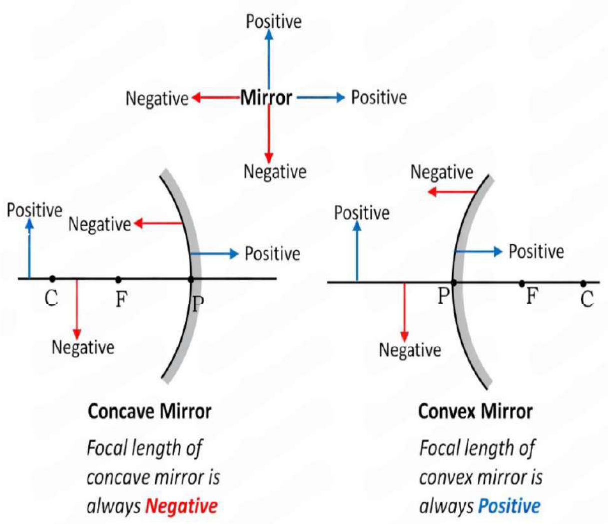
(Converging in nature)

	Object	Image	Nature
1.	∞	Focus	Real and Inverted, extremely diminished
2.	Beyond C	C and F	Real and Inverted, diminished
3.	At C	At C	Real and inverted, equal
4.	B/W C and F	Beyond C	Real and inverted, enlarged
5.	At F	∞	Real and inverted, highly enlarged

Image Formation of Convex Mirror (Diverging in nature)

Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At the focus F, behind the mirror	Highly diminished, point-sized	Virtual and erect
Between infinity and the pole P of the mirror	Between P and F, behind the mirror	Diminished	Virtual and erect

Sign Convention of Sperical Mirror



Numericals

Sign convention

u: object distance → -ve (always)

v: image distance

f: focal length → Concave: -ve, Convex: +ve

R: radii of curvature

$R = 2F$

$F = \frac{R}{2}$

Mirror Formula

$$\boxed{\frac{1}{v} + \frac{1}{u} = \frac{1}{f}} \rightarrow \boxed{\text{Magnification} = \frac{h_i}{h_o} = -\frac{v}{u}}$$

h_i: Height of image

h_o: Height of object

- M = 2 (image size is twice the size of an object)
- M = -2 (image is real and inverted)
- M = 0.2 (image size is smaller than the object)

An object, 4.0 cm in size, is placed at 25.0 cm in front of a concave mirror of focal length 15.0 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image?

Find the nature and the size of the image.

Given:

$u = -25$ cm

$f = -15$ cm

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} + \left(\frac{-1}{25}\right) = -\frac{1}{15}$$

$$\frac{1}{v} = \frac{1}{25} - \frac{1}{15}$$

$$\frac{1}{v} = \frac{3-5}{75}$$

$$\frac{1}{v} = \frac{-2}{75}$$

$$\frac{-75}{2} = -37.5 \text{ cm}$$

Inverted and real

$$\frac{h_i}{4 \text{ cm}} = \frac{-37.5}{-25}$$

$$\frac{37.5 \times 4}{25}$$

$h_i = -6$ cm

Enlarged image

Uses of Mirror

Concave → Magnifying

- Shaving mirror
- Torchlight
- Dentist mirror

Able to view when the image is between focus and pole

- Used in solar furnace

Convex → Diminishing

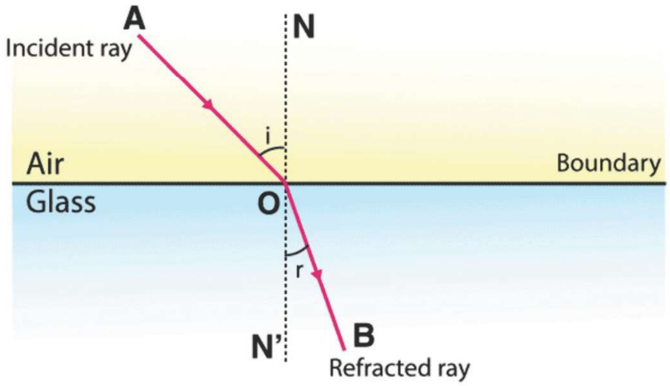
Rear view mirror in vehicle

Security reasons → In ATMs

Sunglasses

Reflection in street light

Refraction of Light



Types of Medium

1. Rare Medium
2. Denser Medium

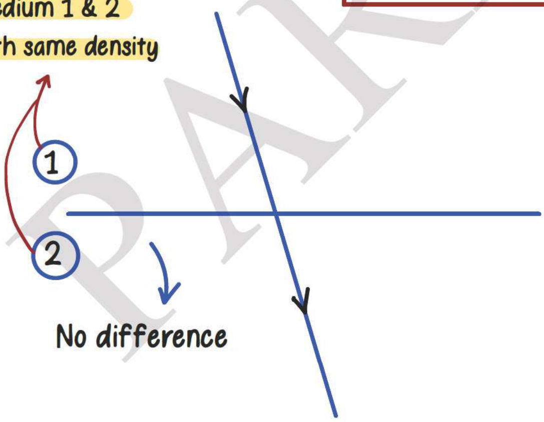
   → Medium with more Density

Air: rarer
Water
Glass: denser

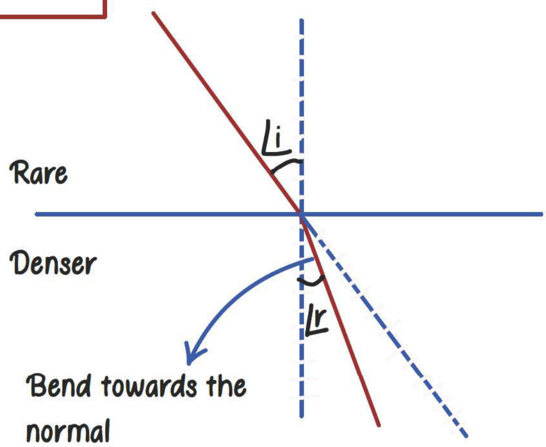
When a ray of light travels, its path changes

Case A

Medium 1 & 2 with same density



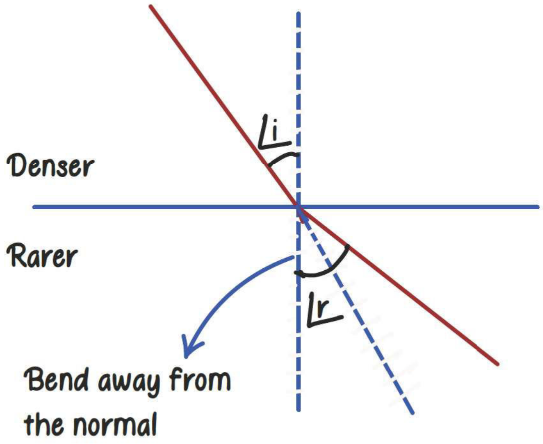
Case B



$\boxed{\angle i > \angle r}$

- Light has rectilinear motion (exhibits straight line)

Case C



$\angle i < \angle r$

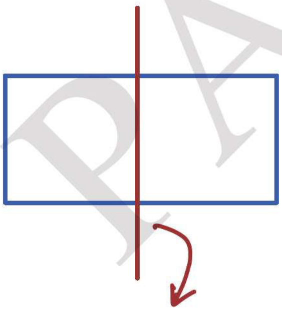
Laws of Refraction

1. Incident ray, refracted, ray and normal ray → all lie in same plane
2. $\dfrac{\sin i}{\sin r}$ = constant → Given pair of media and light of particular wavelength

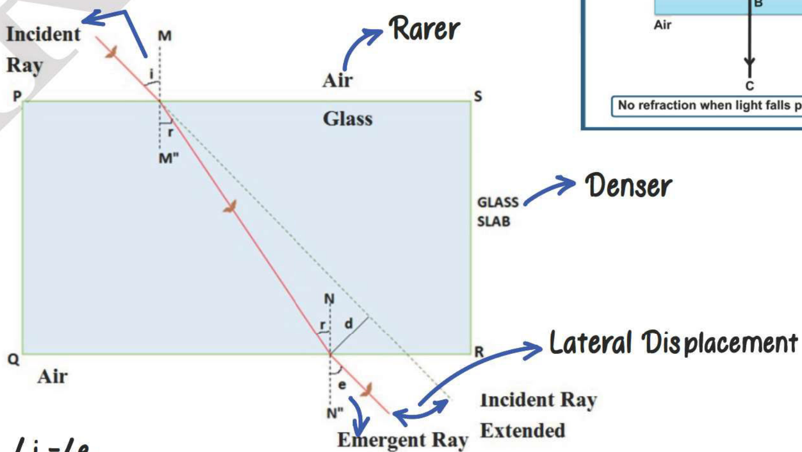
   μ = refractive index   Two mediums

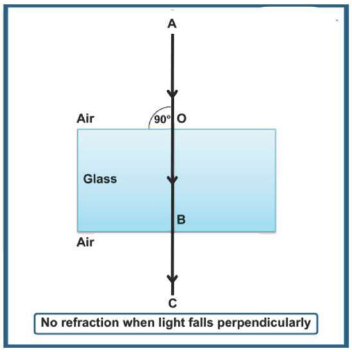
   $= \dfrac{n_2}{n_1}$

Refraction through a Glass Slab



No refraction if strikes at 90°





$\angle i = \angle e$

Angle of incidence = angle of emergence

Refractive Index → Represented with "n" or "μ"

$$\boxed{n = \frac{\text{Speed of light in air/vacuum}}{\text{Speed of light in given medium}}}$$

$$\boxed{n_{QP} = \frac{V_P}{V_Q}}$$

$\boxed{\text{Speed of light in air/vacuum: } 3 \times 10^8 \text{ m/s}}$

Material medium	Refractive index	Material medium	Refractive index
Air	1.0003	Canada Balsam	1.53 1.33
Ice	1.31		
Water	1.33	Rock salt	1.54
Alcohol	1.36		
Kerosene	1.44	Carbon disulphide	1.63
Fused quartz	1.46	Dense flint glass	1.65
Turpentine oil	1.47	Ruby	1.71
Benzene	1.50	Sapphire	1.77
Crown glass	1.52	Diamond	2.42

Densest medium

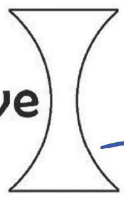
Spherical Lens

- Lens is transparent
- Forms image through refraction

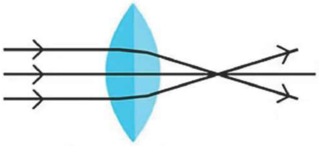
Convex

Centre bulged
Ends narrow

Concave

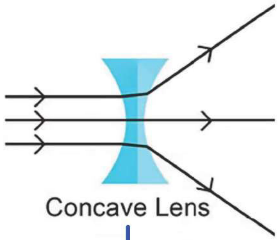


Centre narrow
Ends wider



Convex Lens

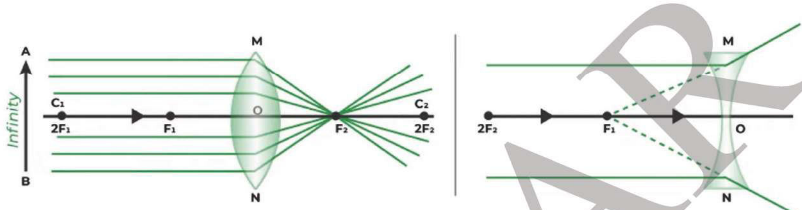
Converging lens



Concave Lens

Diverging lens

Image Formation



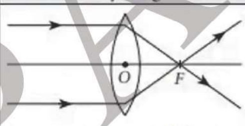
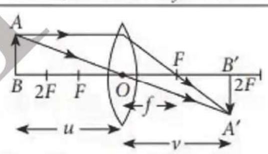
Convex Lens = Concave Mirror
(Converging Lens)

Concave Lens = Convex Mirror
(Diverging Lens)

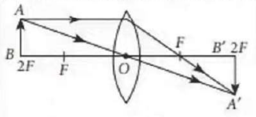
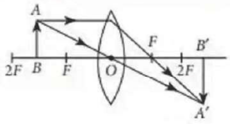
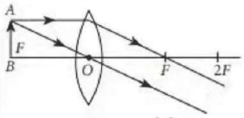
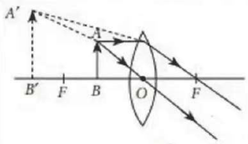
Image Formation in Convex Lens

Same as Concave Mirror

▸ **Image formation by lenses :**

Convex lens				
	Ray diagram	**Position of object**	**Position of image**	**Nature of image**
(a)	 $u = -\text{ve}$, $v = +\text{ve}$ and $f = +\text{ve}$	At infinity	At F	Real, inverted and highly diminished
(b)	 $u = -\text{ve}$, $v = +\text{ve}$ and $f = +\text{ve}$	Between infinity and $2F$	Between F and $2F$	Real, inverted and diminished

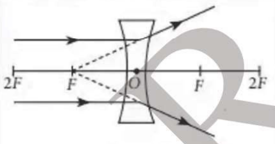
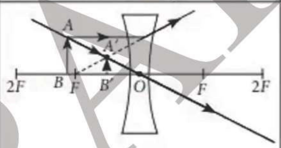
Beyond C (same)

(c)	 $u = -ve$, $v = +ve$ and $f = +ve$	At 2*F*	At 2*F*	Real, inverted and same sized
(d)	 $u = -ve$, $v = +ve$ and $f = +ve$	Between *F* and 2*F*	Beyond 2*F*	Real, inverted and enlarged
(e)	 $u = -ve$, $v = +ve$ and $f = +ve$	At *F*	At infinity	Real, inverted and enlarged
(f)	 $u = -ve$, $v = -ve$ and $f = +ve$	Between *F* and *O*	On the same side of the lens	Virtual, erect and enlarged

Lens Formula = $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

Image Formation of Concave Lens

Same as Convex Mirror

Concave lens				
	Ray diagram	**Position of object**	**Position of image**	**Nature of image**
(a)	 $u = -ve$, $v = -ve$ and $f = -ve$	At infinity	At *F*	Virtual, erect and highly diminished
(b)	 $u = -ve$, $v = -ve$ and $f = -ve$	Between infinity and *O*	Between *F* and *O*	Virtual, erect and diminished

Uses

Concave Lens

- In treatment of Myopia

Used as converging lens

Convex Lens

- In treatment of Hypermetropia
- Used as magnifying lens
- In camera lens

magnification of convex inversely proportion to focal length

A concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens?
Also, find the magnification produced by the lens.

$f = -15$ cm
$u = ?$
$v = -10$ cm

Lens formula $= \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Magnification formula $= \frac{h_i}{h_o} = \frac{v}{u}$

$\frac{1}{u} = \frac{1}{v} - \frac{1}{f}$

$\frac{1}{u} = \frac{1}{-10} - \frac{1}{-15}$

$\frac{1}{u} = \frac{1}{15} - \frac{1}{10}$

$\frac{1}{u} = \frac{2-3}{30} = \frac{-1}{30}$ → $\frac{1}{u}$

$u = -30$

$m = \frac{-10}{-30}$

$m = \frac{1}{3}$ — Erect, virtual, and diminished image

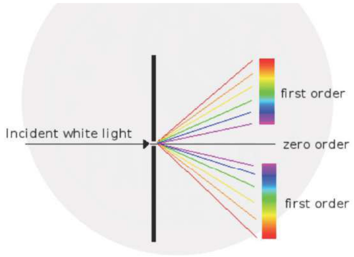
$m = 1 \rightarrow$ object size = image size (same size)
$m < 1 \rightarrow h_o > h_i$ (Diminished)
$m > 1 \rightarrow h_o < h_i$ (Enlarged)

Power of Lens

Power $= \frac{1}{\text{Focal Length}} \rightarrow \frac{1}{m} = m^{-1} \rightarrow$ Dioptre (S.I unit of power of lens)

Focal Length → +ve → Convex
Focal Length → -ve → Concave

Diffraction: it is bending of light around the corner of an obstacle



Question

- Convex lens = 5cm
- Concave lens = 10 cm −10
- Convex lens = 2 cm

When all the focal length is added what power do we get?

Sol: $P = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$

$$P = \frac{100}{5} - \frac{100}{10} + \frac{100}{2}$$

$$= 20 - 10 + 50$$

$$P = 60$$

- A convex mirror, where the object is placed at 10m with focal length of 5m and height of object is 2m. What is the height of image?

$$M = \frac{h_i}{h_0} = -\frac{V}{u}$$

$$\frac{-\frac{10}{3}}{-10} = \frac{10}{3} = \frac{1}{3}$$

$$h_i = m \times h_0$$

$$= \frac{1}{3} \times 2$$

$$= \frac{2}{3}$$

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

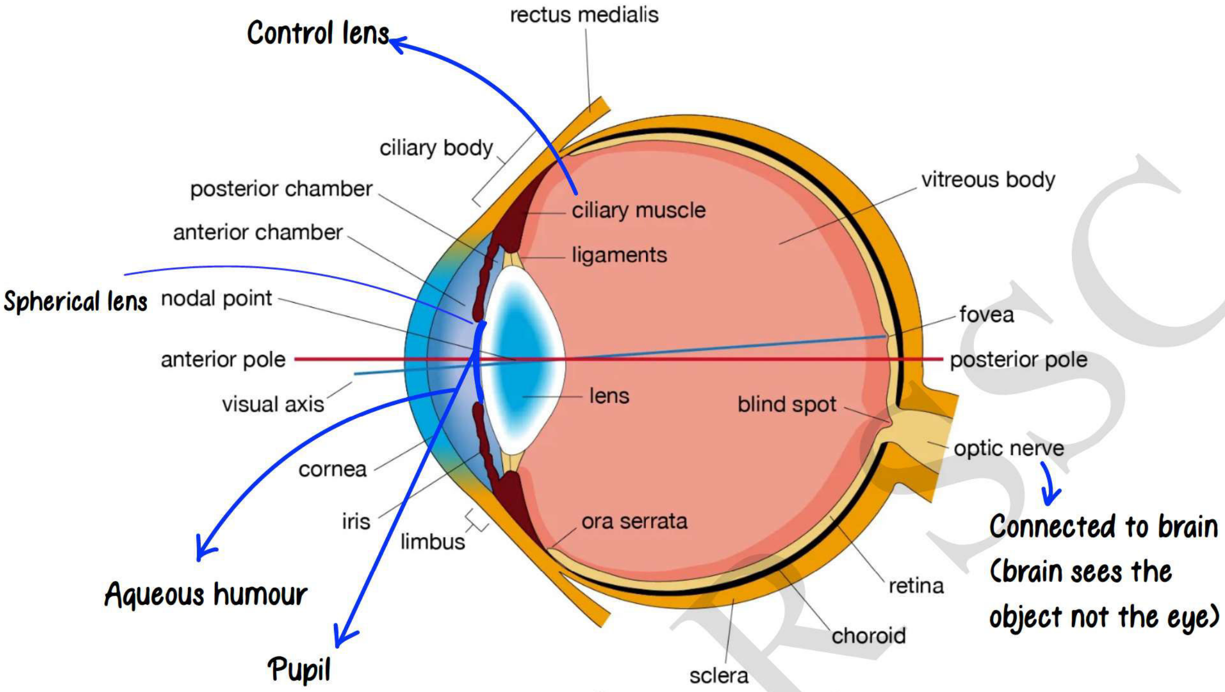
$$\frac{1}{5} = \frac{1}{-10} + \frac{1}{v}$$

$$\frac{1}{v} = \frac{1}{5} + \frac{1}{10}$$

$$\frac{1}{v} = \frac{2}{10} + \frac{1}{10}$$

$$v = \frac{3}{10}\,m = \frac{10}{3}$$

Human Eye & Vision



Eye: Click images/formation

Cornea
- Outermost part
- Causes refraction of light
- Used in eye donation

Aqueous humour provide lubrication to eyes
- Provides nourishment to cornea
- Maintains eye pressure

Vitreous Humour - responsible for the seeing colors.

Ciliary Muscles responsible for change in focal length of eye (b/c it control lens)

Myopia / Hypermetropia / presbyopia happen when lens b/c defective

Iris
- Dark muscular structure
- Controls the size of pupil
- It also determines colour of the eye

Pupil
- To control the amount of light entering the eye

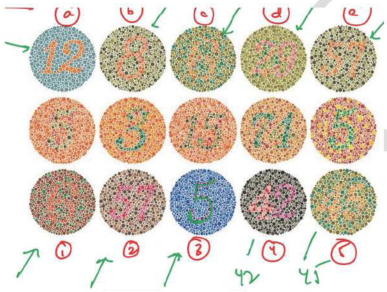
Rod Cell - Black & White
Cone Cell - colors

Lens
- focuses the light ray on the retina

Retina
- It is the spot where image is formed
- Here optical energy is converted to electrical energy

Blind Spot
- Optic nerves meet retina
- No image is formed here

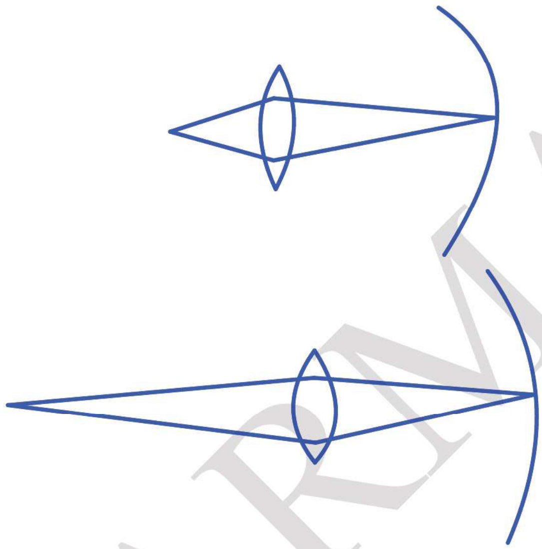
Colour Blindness
- It is hereditary
- Retina made of cone cells (not present in colour blinded people) and rod cells (Light intensity)



Power of Accommodation

Far limit: ∞

- Eye can change focal length (situation based) → Ciliary muscles

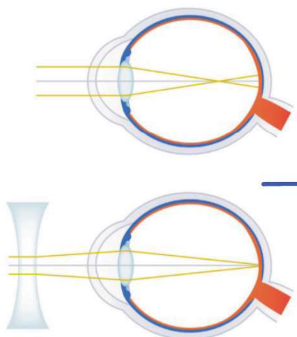


- Least distance of distance of distinct vision: 25 cm

Defects of Eye

Myopia/Near Sightedness
- Far object not visible clearly
- Correction: –ve power lens → Concave lens

Short-sightedness = It is a defect of vision in which a person can see near objects clearly but distant objects appear blurred.

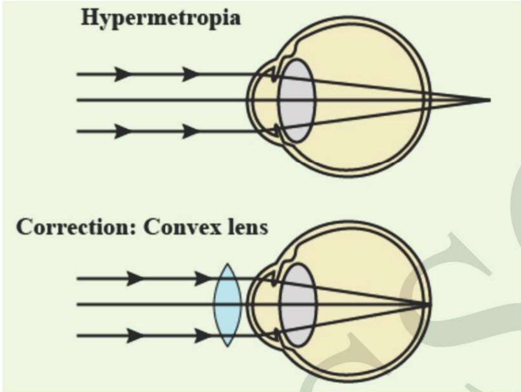


→
- Focal length decreases and Power increases
- Image is formed in front of the retina

Hypermetropia/Far Sightedness → Cannot see nearby objects

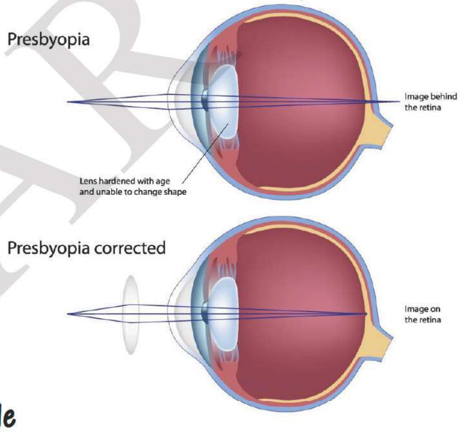
- Image formed behind the retina
- Light focuses behind the retina
- instead of focusing on the retina
- Correction: +ve lens → Convex lens
- Usually occurs above 40 yrs

far-sightedness



Presbyopia

- Lens hardens with age → Loses flexibility
- Age: 50+
- Correction: Concave + Convex lens (Bifocal lens)



Glaucoma/Trachoma

- Both caused due to increase in eye pressure
- Glaucoma is hereditary
- Trachoma is bacterial infection

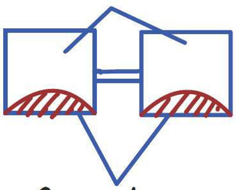
→ Not curable

Peripheral /side vision is impacted

- Tonometre: to measure your eye pressure

Also known as interocular pressure

Concave lens



Convex lens

Colour Blindness

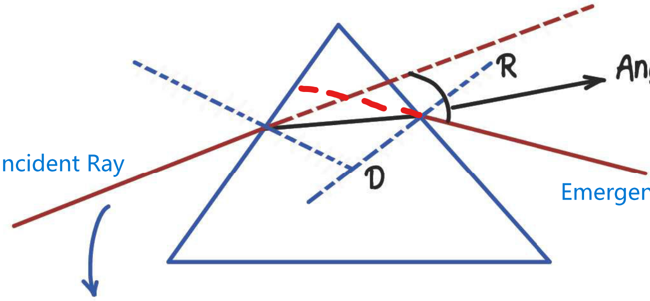
- It is hereditary
- Retina made of cone cells and rod cells

↓

Not present in colourblind people

- Cataract: The clear lens of the eye becomes cloudy and the vision becomes blurry. This clouding happens as the proteins in the lens break down and clump together.

Refraction of Light by a PRISM



Angle of Deviation

↓

Wavelength

Wavelength↑ Deviation↓

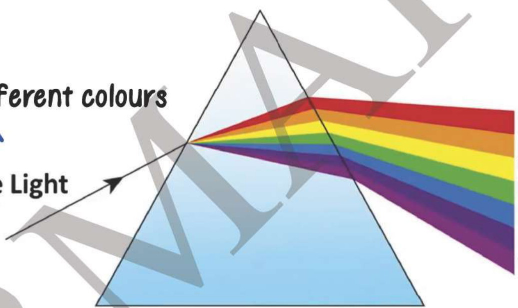
Ray of light away from the normal

Dispersion of White Light in a Glass Prism

Consist of 7 different colours

↑

White Light



longest/

- Highest wavelength
- Less deviation

Red
Orange
Yellow
Green
Blue
Indigo
Violet

More deviation

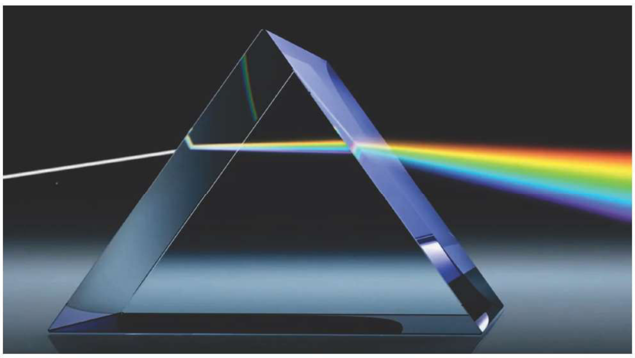
Decreasing wavelength

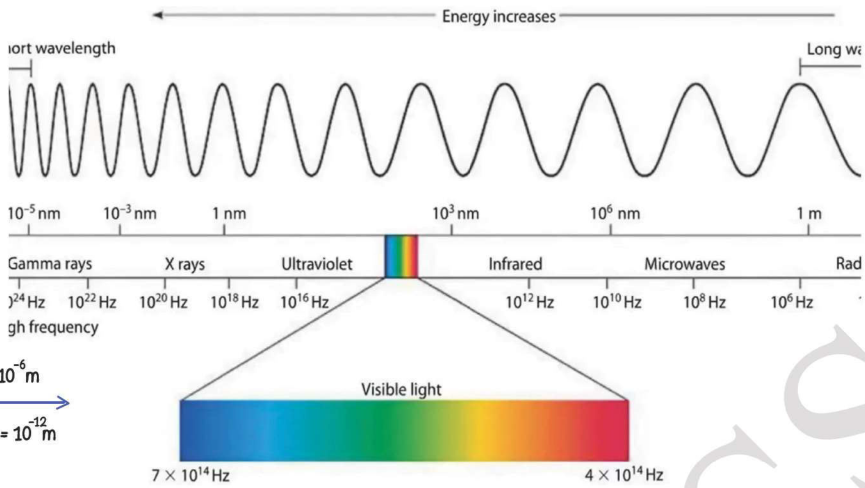
Increasing frequency/ energy order

Red: more speed → Less refractive index

Violet: less speed → More refractive index

$$n = \frac{\text{Speed of light in air}}{\text{Speed of light in prism}}$$





$1\ nm = 10^{-9} m$ $\quad$ $1\ u = 10^{-6} m$

$1\ Å = 10^{-10} m$ $\quad$ $1\ pm = 10^{-12} m$

Electromagnetic Spectrum

TRICK

Rich → Radio waves (By Heinrich Hertz in 1880s)

Man → Micro waves (Percy Spencer (1942))

in → Infrared (William Hershel (1800))

Victor → Visible

Uses → UV rays (Johann Wilhem Ritter (1801))

X → X-ray (Wilhem Rontgen (1901))

Gold → Gamma rays (Paul Villard (1900))

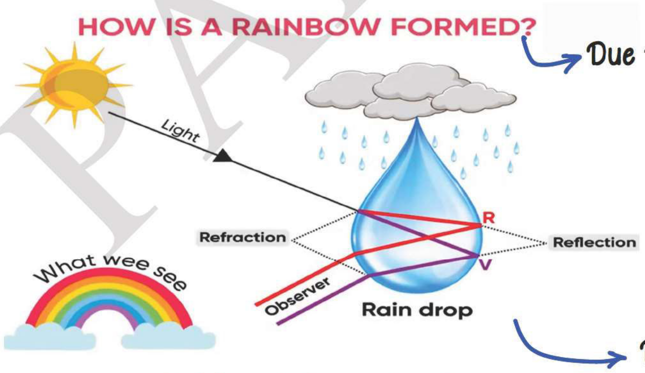
Left to right Wavelength decreases and frequency increases and energy increases

frequency → SI unit: Hertz

$$\boxed{E = hf \qquad E = \frac{hc}{\lambda}}$$

h → Planks constant

λ → wavelength



→ Due to dispersion

↓

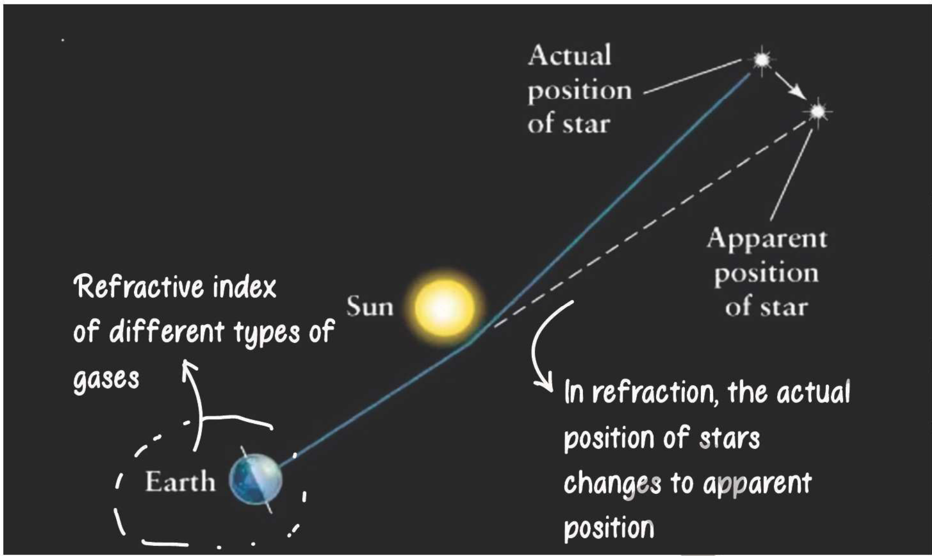
2 refraction and 1 reflection

→ Dispersion of white light here

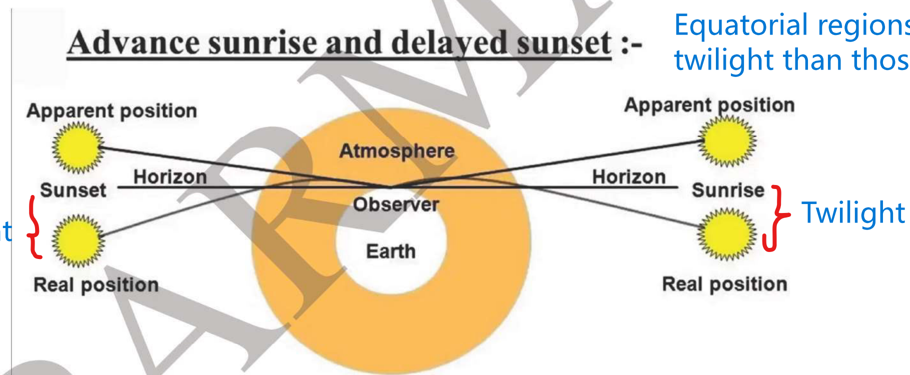
→ Rainbow is formed to the opposite direction of the Sun

Refraction in Atmosphere

Twinkling of Stars → Due to affects of the Earth's atmosphere (atmospheric refraction of star light)



Advance Sunrise and Delayed Sunset



Equatorial regions witness shorter twilight than those at higher latitudes.

- In this phenomenon, the sun appears to rise early by two minutes and set late by two minutes. When the rays from the sun hit atmosphere, they get refracted

Refraction – early sunrise & delayed sunset, twinkling of star, Used in lenses, spectacles, microscopes telescopes, cameras, magnifying glass.
Reflection – Used in mirrors, periscopes, solar cookers, rear-view mirrors.
Total Internal Reflection (TIR) – Used in optical fibers (internet, medical endoscopy), prisms, binocula diamond sparkle.
Scattering – Explains blue color of sky, red color of sunrise/sunset, used in smoke detectors and Ram spectroscopy.

Scattering of Light

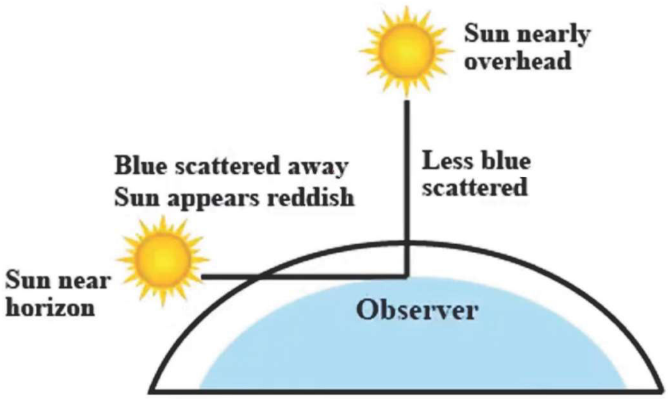
Rayleigh scattering

- Scattering of light by molecules and particles in the atmosphere.

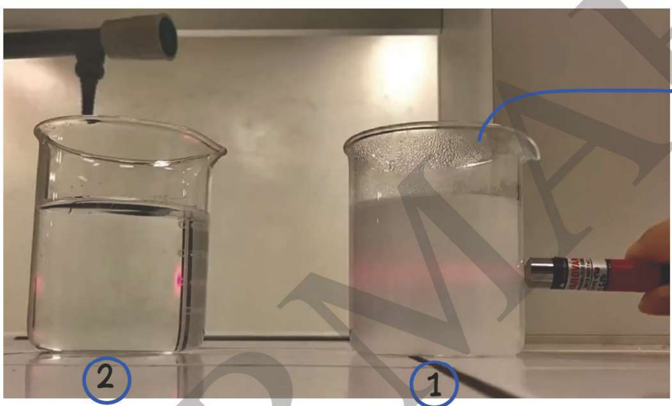
- Blue colour of sky: blue light is scattered more than the other colours because it travels as shorter, smaller waves
- Our sky appears black without atmosphere

- Red colour of Sun during sunrise and sunset: red light scatter the least by the molecules present in the air, so at sunset and sunrise, the sunlight travels longer path through the atmosphere to reach our eyes. The blue light catches the most and has been mostly removed, leaving the red light remaining which reaches our eyes.

More wavelength



Tyndall Effect



Colloidal solution scatter the light most because the dispersed particles of colloid are bigger and they defect light

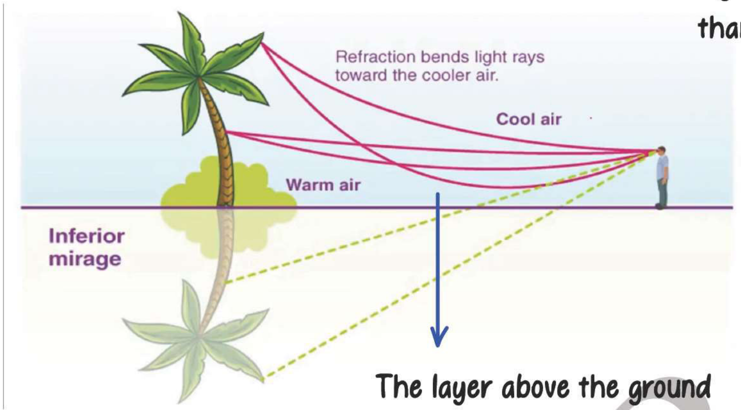
Why are danger signs red?

→ Red has maximum wavelength and is least scattered allowing it to travel long distances without getting scattered

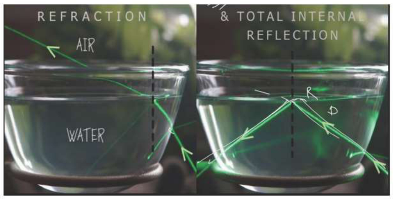
Total Internal Reflection

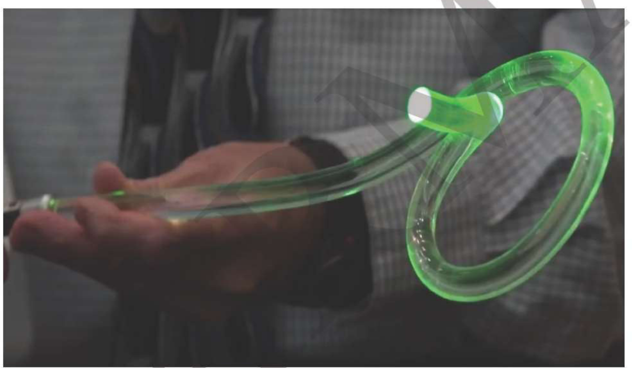
- This phenomenon is responsible for optical illusions
  Examples: Mirage, optical fibers

- Condition of TIR
  1. Light should travel from denser to rare medium
  2. light should hit an angle greater than critical angle



The layer above the ground gets warmed. The light ray gets refracted when light moves through the cold air and into the hot air layer → Total internal reflection





Optical Fibers

- Optical Fibers Uses
  Telecommunications, Medicine, Data storage, and Industrial processes

Electricity

What is Electric Current?

- Flow of charge per unit time
- Flow of electrons per unit time

↳ $1\ e^- = 1.6 \times 10^{-19}$ Coulomb

↳ S.I unit of charge

$q = n \times e^-$

$1\ C = n \times 1.6 \times 10^{-19}$

$n = 6 \times 10^{18}\ e^-$

- Galvanometer measures small Electric Current
- Electric current is measured by Ammeter
- Current S.I unit: Ampere

Electric Current

$i = \frac{q}{t}$ (q)

$q = i \times t$

Charge

+ve   -ve

Current = $\frac{\text{Charge}}{\text{Time}}$

- Like charges repel each other
- Opposite charges attracts each other

- Conductor: is a material that conducts electricity/allows electron to flow through it

Potential Difference

- The amount of work done in moving a unit positive charge from one point to other in an electric field

Potential difference

$V = \frac{W}{q}$

Work done to move the charge

- Measured though: Voltmeter
- S.I unit: Volt

1 volt: if one Joule of work is done in moving, one coulomb of charge

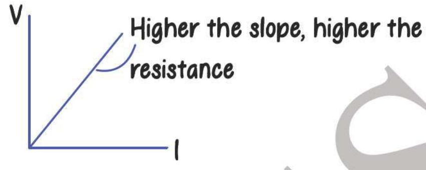
$1V = \frac{1J}{1C}$

Ohm's Law

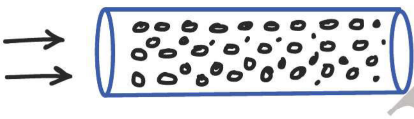
→ The current flowing in a conductor is directly proportional to the voltage across the conductor, provided all the physical condition and temperature remain constant

- By George Simon Ohm in 1827
- $V\uparrow \propto I\uparrow$
- $\boxed{V = IR}$

R → Resistance → S.I unit Ohm (Ω)



- **Resistance**: the property of a conductor to resist the flow of charge through it



- **Factors effecting Resistance**

1. Length → Length↑ Resistance↑ (More collision of electrons)
2. Area of cross-section → Area↑ Resistance↓ (Less collision of electrons)
3. Temperature → Temperature↑ Resistance↑
   → Increase movement of e^- and K.E
4. Nature of material

$R \propto L$

$R \propto \frac{1}{A}$

$R \propto \frac{L}{A}$

$R = \frac{\rho L}{A}$

ρ → Resistivity/Specific resistance

ρ = mho/ohm^{-1}

$\Omega = \rho \frac{\cancel{m}}{m^{\cancel{2}}}$

$\boxed{\Omega\, m = \rho}$ → S.I unit

The resistivity of a material is the resistance of a wire of that material

- Resistivity is a constant value
- Resistivity doesn't depend on parallel or series, it depends on the properties of that material

	Material	Resistivity (Ω m)
Conductors	Silver	1.60×10^{-8}
	Copper	1.62×10^{-8}
	Aluminium	2.63×10^{-8}
	Tungsten	5.20×10^{-8}
	Nickel	6.84×10^{-8}
	Iron	10.0×10^{-8}
	Chromium	12.9×10^{-8}
	Mercury	94.0×10^{-8}
	Manganese	1.84×10^{-6}
Alloys	Constantan (alloy of Cu and Ni)	49×10^{-6}
	Manganin (alloy of Cu, Mn and Ni)	44×10^{-6}
	Nichrome (alloy of Ni, Cr, Mn and Fe)	100×10^{-6}
Insulators	Glass	$10^{10} - 10^{14}$
	Hard rubber	$10^{13} - 10^{16}$
	Ebonite	$10^{15} - 10^{17}$
	Diamond	$10^{12} - 10^{13}$
	Paper (dry)	10^{12}

Alloy has greater resistivity than its constituent metals

Types of Materials

- Conductor: materials that conduct electricity/allow electric flow through them → Has free electrons

  Seen in metals

- Semi-conductor: they are materials which have conductivity between conductors and non-conductors or insulator. Eg: Silicon (usually Metalloids)
- Insulator: materials that do not allow electricity to pass through them. Eg: Non-metals such as glass, wood

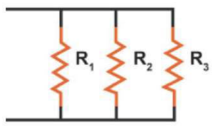
Resistance of a System of Resistance

Types:

1. Series
2. Parallel

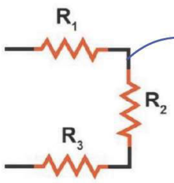
Parallel: same potential difference; different current

Parallel



Parallel Circuit

Series



Series Circuits

Series: same current; different potential difference

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots$$

R_{eq} (Parallel) < R_{eq} (Series)

$$R_{eq} = R_1 + R_2 + R_3 + R_4 + \ldots\ldots$$

Q. 2 resistors = 20Ω and 4Ω (Series)
Connected to a 6 volt battery
Current flow?

→ $V = IR$

$R_{eq} = R_1 + R_2$

$20 + 4 = 24\Omega$

$6\,V = I \times 24\Omega$

$\frac{\cancel{6}^{1}}{\cancel{24}_{4}} = I$

$0.25\,A = I$

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{20} + \frac{1}{4}$

$= \frac{1+5}{20}$

$= \frac{20}{6}$

$6 = I \times \frac{20}{6}$

$I = \frac{36}{20}$

$= \frac{9}{5}$

Or (two resistors connected in parallel)

$\frac{1}{R_{eq}} = \frac{20 \times 4}{20 + 4}$

$= \frac{80}{24}$

$= \frac{10}{3}$

Q. $R_1 = 5\Omega$; $R_2 = 10\Omega$; $R_3 = 30\Omega$ → Parallelly connected
P.d = 12 V
Current?

→ $V = IR$

$12 = I \times 5$

$\frac{12}{5} = I$

$2.4\,A = I$

$V = IR$

$12 = I \times 10$

$1.2\,A = I$

$V = IR$

$12 = I \times 30$

$0.4\,A = I$

→ $2.4 + 1.2 + 0.4 = 4.0\,A$

OR →

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R_{eq}} = \frac{1}{5} + \frac{1}{10} + \frac{1}{30}$

$\frac{1}{R_{eq}} = \frac{6+3+1}{30}$

$\frac{1}{R_{eq}} = \frac{10}{30}$

$R = 3\Omega$

$V = IR$

$\cancel{12}^{4} = I \times \cancel{3}$

$I = 4\,A$

Heating effect of Electric Current

By James P. Joule

$$V = \frac{W}{q} \qquad \text{Power} = \frac{\text{Work Done}}{\text{Time}}$$

Substituting

$$\text{Electric Power} = \frac{qV}{t}$$

Electric Power = VI

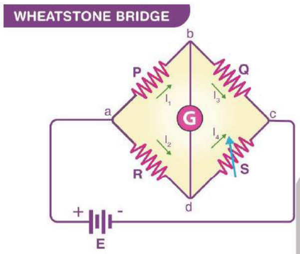
Heat = Power x t

Heat = VIt

IR x IT

$I^2RT = H$

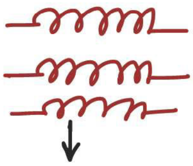
Wheatstone Bridge



$$\frac{P}{R} = \frac{Q}{S}$$

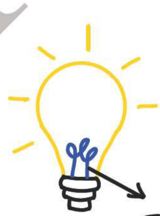
- A Wheatstone bridge is an electrical circuit used to accurately measure an unknown resistance by balancing two legs of a bridge circuit

Practical Applications of Heating Effect of Electric Current



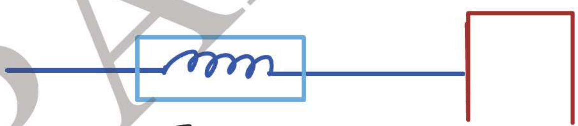
Coils in heater made of Nichrome

Alloy of Ni and Cr



- Filament made of Tungsten (W)
- Has high melting point

Fuse wire should have Low Melting Point & High Resistance



Fuse

- Low melting point
- It is used to protect electrical appliances from excessive current and to prevent short circuits or mismatched loads

Current increases sharply

- Closed circuit: switch on
- Open circuit: switch off

power = work done / time or power = energy / time
energy = power * time
energy = 1000w * 60 * 60s

Electric Power

$P = VI$

$P = I^2R$ ← $V = IR$

$P = \frac{V^2}{R}$ $\frac{V}{R} = I$

Commercial Unit of Energy

1 unit = 1 kWh

$P \times t$ 1 kW = 1000 W

$1000 \times 3600s$

36×10^5 Ws

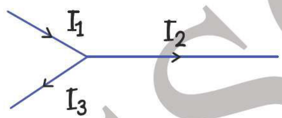
3.6×10^6 J ⟶ 1 unit

1 hr = 60 mins

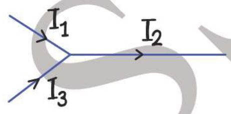
60 x 60 = 3600 secs

Kirchoff's Law

1. **Law of Current:** It states that he total current entering a node (junction) in a circuit is equal to the total current leaving that node.
2. **Law of Voltage:** The sum of all voltages (EMFs and voltage drops) around any closed loop in a circuit is equal to zero. $\Sigma V = 0$



$I_1 = I_2 + I_3$



$I_1 + I_2 = I_3$

At the time of short circuit, current in the circuit increase heavily

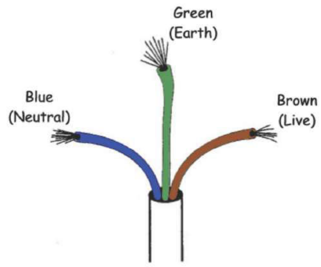
220 V; 50 Hz ⟶ In electric appliances

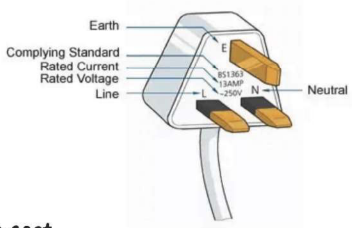
- **Live wire**: Red
- **Neutral**: Black
- **Ground/Earth**: Green/Yellow

Colour of wire

V = 0

Very high voltage





- Calculate the electrical energy consumed by a 1200 W toaster in 30 mins. What will be the cost of using the same for 1 month if 1 unit of electricity cost Rs. 4?

1 unit = 1 Kwh

$= \frac{1200}{1000} \times \frac{30}{60}$

$= \frac{6}{10} \times 30 = 18$ unit x 4 = Rs. 72

Magnetic Effect of Electric Current

Heating Effect of Electric Current, Discoverer: James Prescott Joule (1840s)
Magnetic Effect of Electric Current, Discoverer: Hans Christian Ørsted (1820)

Photosynthesis: convert Light to Chemical

Magnetic Effect of Electric Current

Discovery

- Hans Christian Orsted in 1820

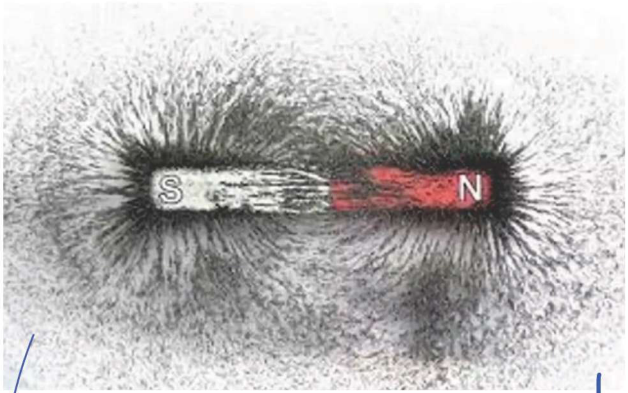
- Heating effect of electric current: James Joule (1840)

Electric current passed through the wire

Causing deflection in the compass whenever there is a current in wire showing current carrying wire produces a magnetic field around it

Direction of magnetic field changes due to change in direction of current in the wire

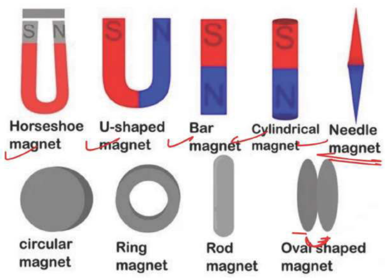
Magnetic Field Lines



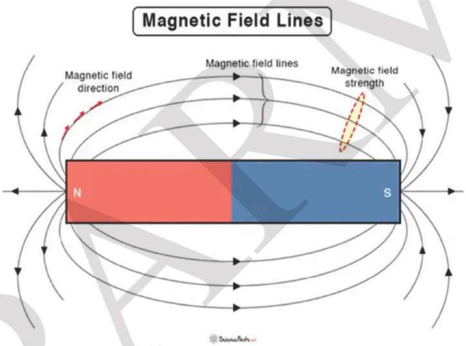
- Like poles repel each other
- Unlike poles attract each other

Closer/denser → stronger

Types of Magnet



Iron fillings align themselves with the magnetic field → when spread across a magnetic bar, they respond to magnetic effect of the bar magnet and align themselves accordingly



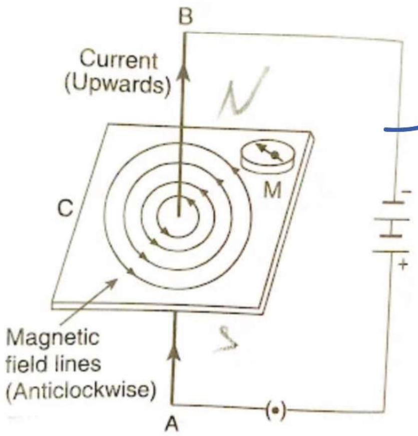
- Magnetic field lines originate from North Pole outside the magnet and terminate at South Pole
- Magnetic field line are in the form of closed loop
- Magnetic field lines never intersect each other

Vector quantity

If they insect, there will be two directions of magnetic field lines which is not possible

- If magnetic field lines are closer → Magnetic Field ↑

Magnetic Field due to a Current Carrying Conductor



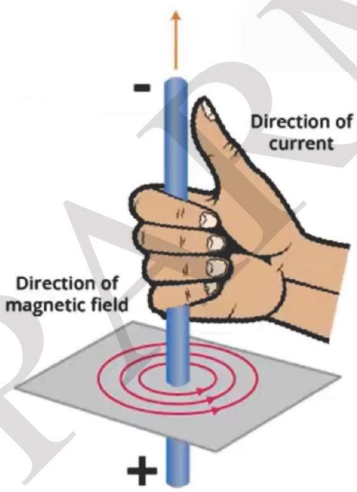
- Magnetic field lines around a straight conductor carrying current are concentric circles whose centre lie on the wire

- Magnetic Field $\propto \frac{1}{\text{Distance}}$

  Distance↑ → Magnetic Field↓

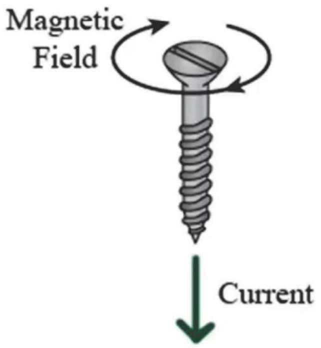
- Current↑ $\propto$ Magnetic Field↑

- Direction of current changes → Direction of Magnetic Field changes

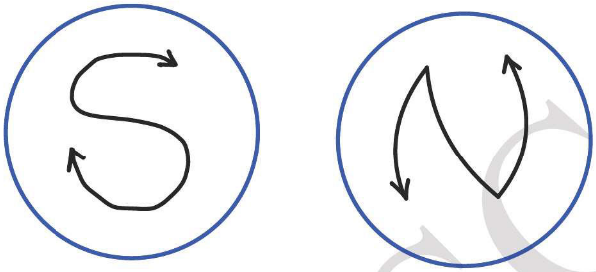


Maxwells Right Hand Thumb Rule to find direction of magnetic field

- Current upwards: Magnetic field → Anti-clockwise
- Current downwards: Magnetic field → Clockwise



South Pole | North Pole

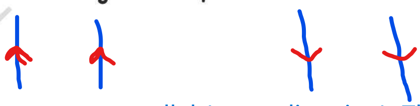


Clockwise | Anti-clockwise

Maxwell's screw rule to find direction of magnetic field in a straight current carrying conductor

Ampere's Law

- It states that the line integral of the magnetic field around a closed loop is proportional to the total current passing through the loop.



If the currents are parallel (same direction): The conductors attract each other.

Magnetic Field due to a Current carrying Circular Loop

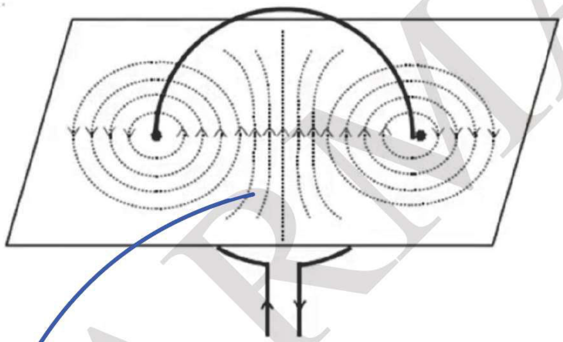


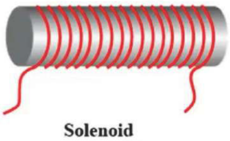
Fig 3.9 Magnetic field due to a circular loop carrying current

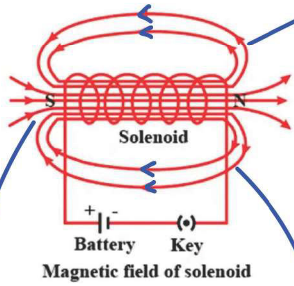
In centre, the magnetic field lines are parallel and uniform

- No. of turns in loop ↑ → Magnetic Field ↑
- Distance ↑ → Magnetic Field ↓
- Current ↑ → Magnetic Field ↑

If the currents are anti-parallel (opposite directions): The conductors repel each other.

Magnetic Field due to a current carrying Solenoid





Behaves like a bar magnet when current is passed

- In a solenoid the magnetic field is maximum inside the solenoid

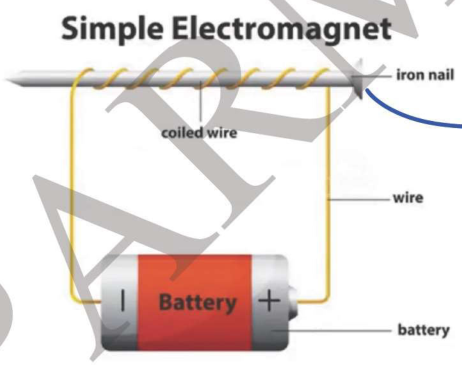
It is uniform

- Current passed through a solenoid
- If direction of current is reversed, the direction of magnetic field is also reversed

Magnetic field lines outside the solenoid is very weak → Considered to be practically zero

Electromagnet

- An electromagnet is a temporary magnet, meaning it only exhibits magnetic properties when an electric current is flowing through its coil, and loses its magnetism when the current is switched off.



Soft iron rod that behaves like a magnet when current is passed through it

Hand me mechanical Energy

gives: force on a current carrying conductor

gives: Direction of Induced current

RC

Fleming's Left Hand Rule (F,B,I)
ex Motor

Fleming's Right Hand Rule (F,B,I)
ex Generator, Dynamo

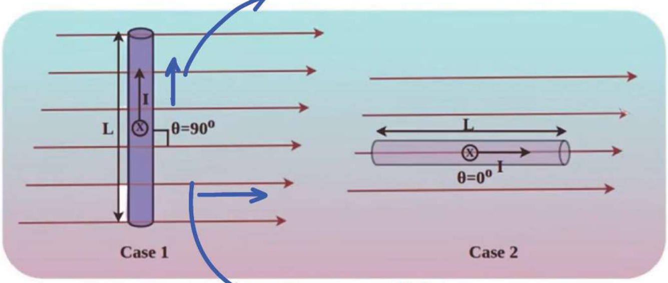
Human ke Andar Electricity hoti he

left-force

Right-current

Force on a Current Carrying Conductor in a Magnetic Field

Current direction upwards



Magnetic field

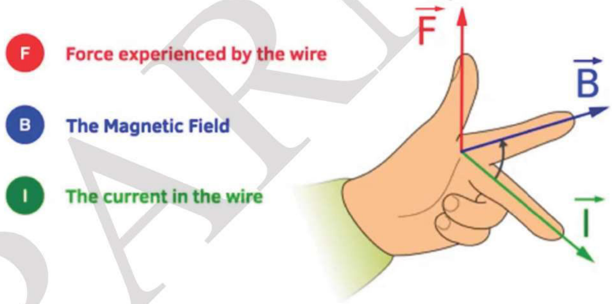
$F = qvB \sin\theta$

Motor works on principle of Fleming's Left Hand Rule

Electric energy ⟶ Mechanical energy

- Force will be ⟶ Maximum: the angle between the conductor and the magnetic field is 90°

  Minimum: The conductor is placed along the direction of magnetic field, whether parallel or antiparallel ⟶ Zero

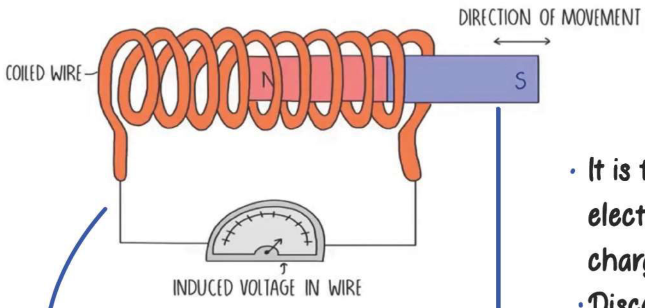


⟶ Used when a current carrying conductor is introduced in an external magnetic field

Fig 1. Fleming's Left Hand Rule.

Electromagnetic Induction

→ Generator work on this concept (Fleming's Right Hand Rule)

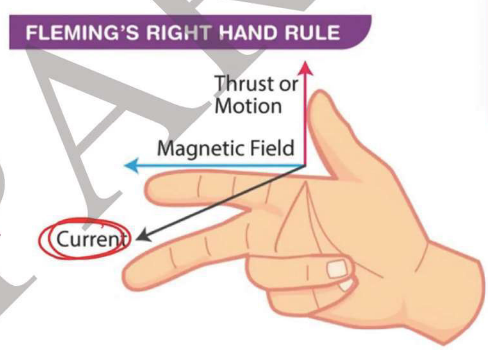


- It is the phenomenon in which electric current is generated by charging magnetic fields
- Discovered by Michael Faraday in 1831

EMI Discovered by

When the bar magnet is pushed towards the coil, the pointer in the galvanometer deflects

The relative motion between the magnet and the coil is responsible for generation of electric current in the coil



Generator → Mechanical Energy → Electrical Energy

Generator (also known as dynamo) changes mechanical energy to electrical energy.

Short circuit: it is caused due to breaking of insulation of wires, forming the contact between live wire and neutral wire

→ Current in a circuit increases abruptly

Live wire: red colour (220V)

Neutral wire: black colour(6V)

Rectifier

DC

Current flows only in one direction

AC

Current changes its direction every 1/100th of a second