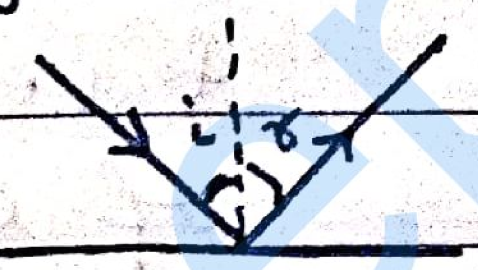
Light

Reflection & Refraction

Laws of reflection:



(i) The angle of incidence is equal to the angle of reflection i.e $\angle i = \angle r$

(ii) The incident ray, the normal to the mirror at the point of incidence & the reflected ray, all lie in the same plane.

Image formation by a concave mirror for diff. position of the object :-

	Position of the object	Position of the image	Size of the image	Nature of the image.
(i)	At ∞	At F	Highly diminished, point size	Real & inverted
(ii)	At F	At ∞	Highly enlarged	Real & inverted
(iii)	Beyond C	Between F & C	Diminished	Real & inverted
(iv)	At C	At C	Same size	Real & inverted
(v)	b/w C & F	Beyond C	Enlarged	Real & inverted
(vi)	b/w P & F	Behind the mirror	Enlarged	Virtual & erect

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Uses of Concave mirrors:

(i) Commonly used in torches, search light & vehicles headlight to get powerful beam of light.
(ii) They are often used as shaving mirror to see a larger image of the face.
(iii) The dentist use concave mirrors to see large image of the teeth of patients.
(iv) Concave mirrors are used to concentrate sunlight to produce heat in solar furnaces.

Nature, position & relative size of the image formed by a convex mirror:-

Position of the object	Position of the image	Size of the image	Nature of the image
(i) At ∞	At the focus F, behind the mirror	Highly diminished, point size	Virtual & erect.
(ii) b/w infinity & the pole P of the mirror	b/w P & F behind the mirror	Diminished	Virtual & erect.

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Uses of convex mirrors:

- used as rear-view (wing) mirror in vehicles

Mirror formula & Magnification

Mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

Magnification (m) $= \frac{h'}{h} = -\frac{v}{u}$

where,
u = object distance
v = image distance
f = focal length
h' = height of image
h = height of object.

[1] (Q) A concave mirror has a focal length of 20 c.m At what distance from the mirror should a 4 c.m tall object be placed so that it forms an image at a distance of 30 c.m from the mirror? Also calculate the size of the image.
[Ans: -60 c.m, -2 c.m]

[2] (Q) An object of height 4 c.m is kept at a distance of 30 c.m from the pole of a diverging mirror. If the focal length of the mirror is 10 c.m, the height of the image formed is ......
[Ans: +1 c.m]

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Sol^n (1) given,
$f = -20$ c.m (due to concave)
$v = -30$ c.m (in the front of mirror)
$h = 4$ c.m
$h' = ?$ $u = ?$

A/c to mirror formula

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

$$\frac{-1}{30} + \frac{1}{u} = \frac{1}{-20}$$

$$\frac{1}{u} = -1/60$$

$$\therefore \boxed{u = -60 \text{ c.m}}$$

Also,

$$m = \frac{h'}{h} = \frac{-v}{u}$$

$$\Rightarrow \frac{h'}{4} = -\frac{(-30)}{-60}$$

$$\Rightarrow \boxed{h' = -2 \text{ c.m}}$$

Sol^n (2) given $f = +10$ c.m (due to convex)
$u = -30$ c.m ; $h = 4$ c.m
$v = ?$ $h' = ?$

A/c to mirror formula

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

$$\frac{1}{v} + \frac{1}{-30} = \frac{1}{10}$$

$$v = \frac{30}{4}$$

Also, $m = \frac{h'}{h} = -\frac{v}{u}$

$$\Rightarrow \frac{h'}{4} = -\frac{30/4}{-30}$$

$$\Rightarrow \boxed{h' = +1 \text{ cm}}$$

Refraction of light :~

Change in path of a light ray as it passes through one medium to another medium is called refraction of light.

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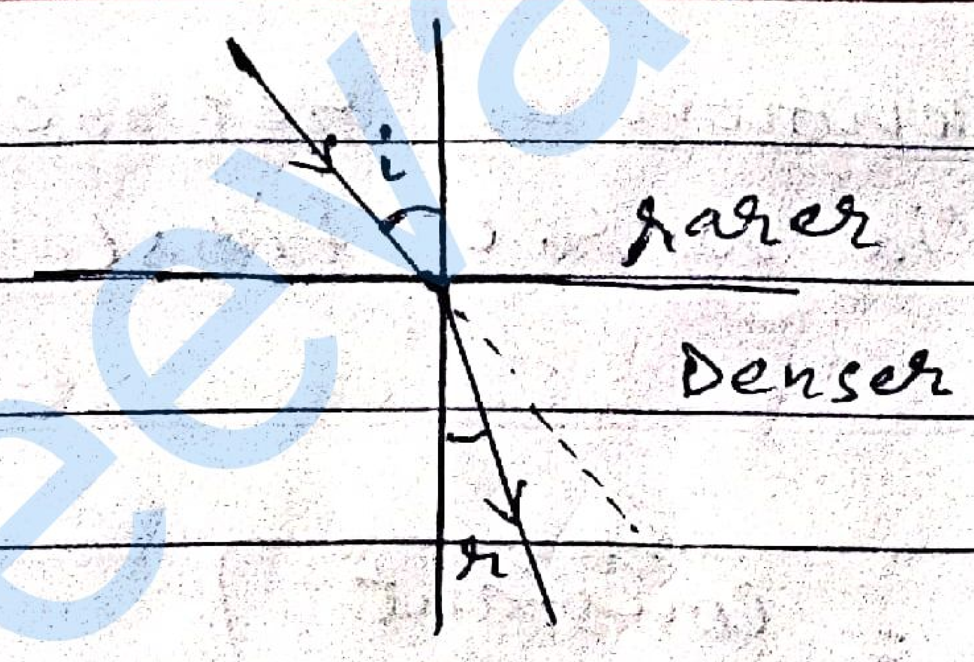
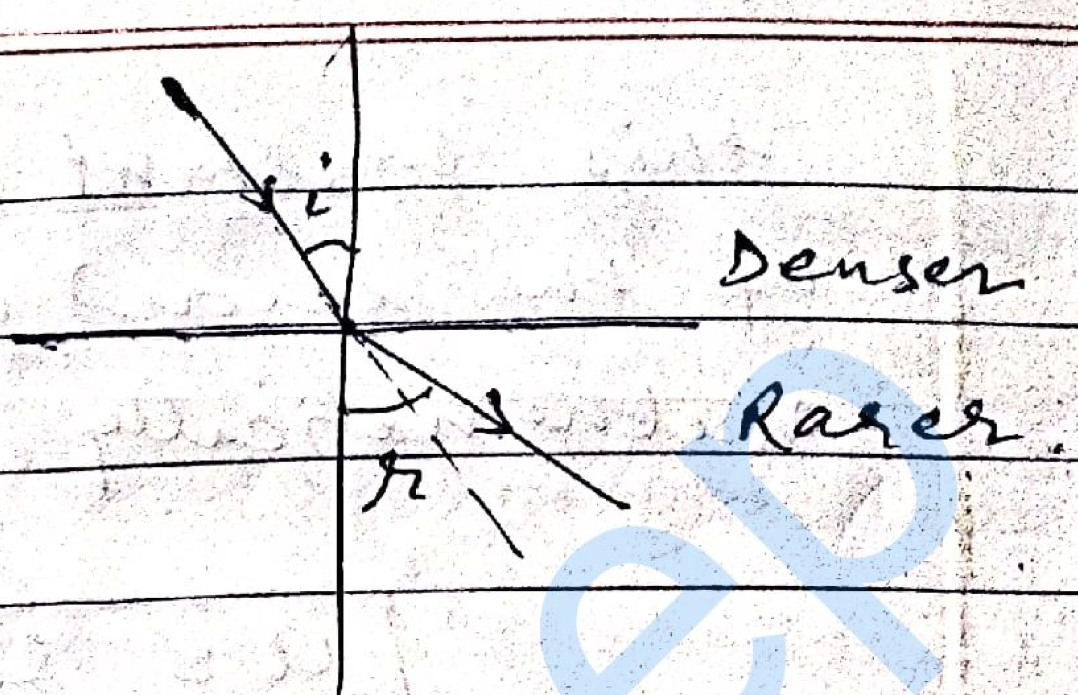




⇒ When light travels from a rarer medium to a denser one, it bends towards the normal ($i > r$).
& when travel from a denser medium to a rarer one, it bends away from the normal ($i < r$).

⇒ The cause of refraction of light is the change in speed of light when it passes from one medium to another.

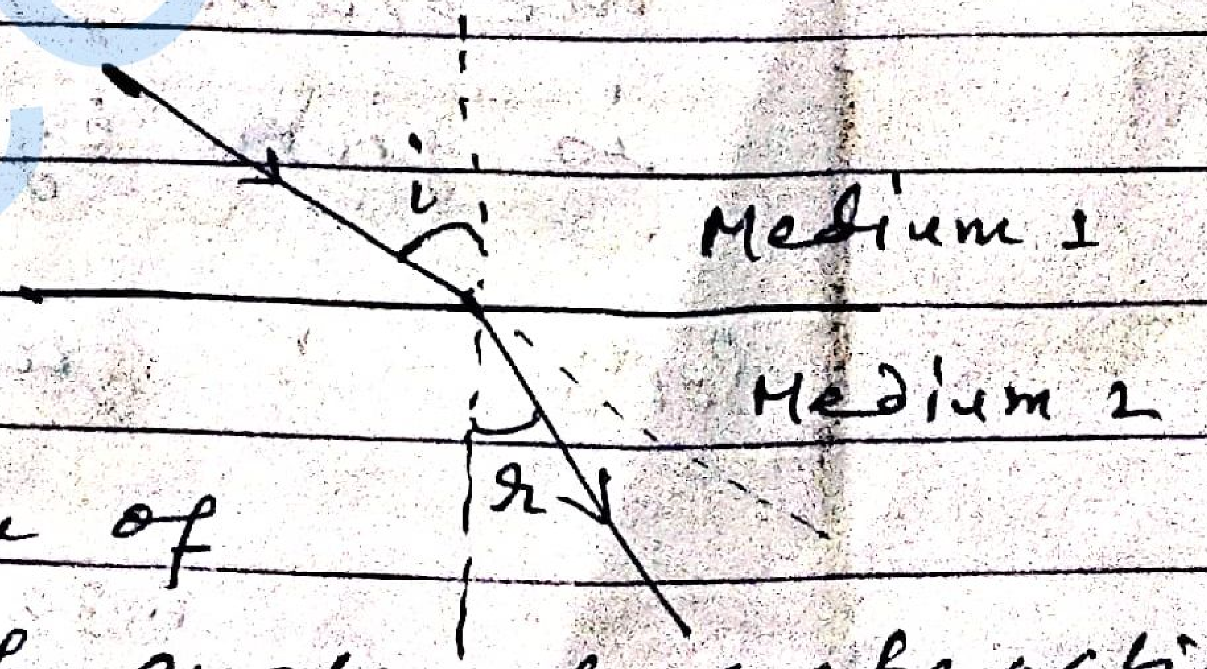
⇒ When light is incident normally i.e. $i = 0$, the speed of light changes but dir^n of light does not change.

Laws of refraction :-

There are two laws of refraction of light which are stated below

(i) First law: The incident ray, the refracted ray & the normal at the point of incidence, all lie in the same plane.

(ii) Second law (or Snell's law) :-



The ratio of sine of angle of incidence to the sine of angle of refraction is constant for a given pair of media.

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this constant is known as refractive index of the second media w.r.t first media.
Mathematically,

$$\mu = \frac{\sin i}{\sin r} = \text{constant}$$

↳ this relation is Also known as Snell's law.

Refractive index:- (or Absolute ref. index)

$$\mu = \frac{c}{v} = \frac{\text{Speed of light in Vacuum or air}}{\text{Speed of light in given medium}}$$

- it has no unit.
- The absolute refractive index of a medium is always greater than 1.
- The relative refractive index can be less than or greater than 1.

[1] Q) if the refractive index of water is 1.33 than determine the speed of light in this medium, if the speed of light in vacuum is given by 3×10^8 m/s.

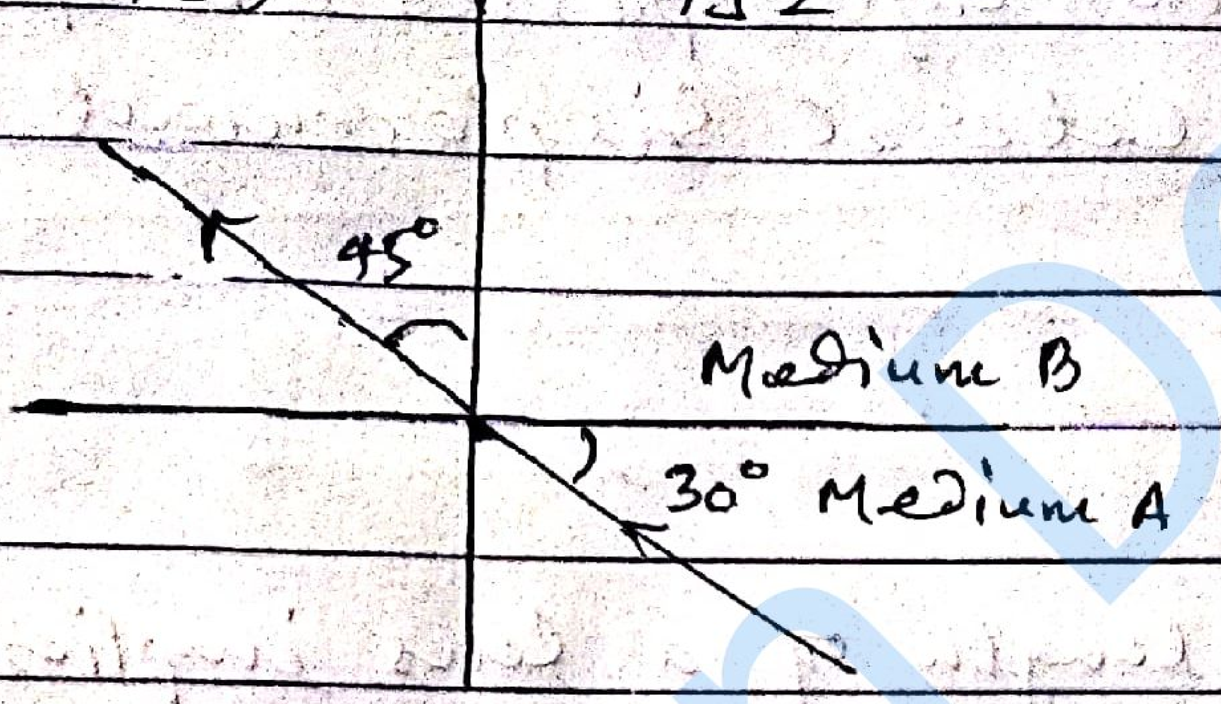
Solⁿ:- $\because \mu = \frac{c}{v}$

$1.33 = \frac{3\times10^8}{v}$

$v = \frac{3\times10^8}{1.33}$

$v = 2.25\times10^8$ m/s

Q. Fig. shows a ray of light as it travels from medium A to medium B. Refractive index of the medium B relative to medium A is -
(a) $\sqrt{3}/\sqrt{2}$ (b) $\sqrt{2}/\sqrt{3}$ (c) $1/\sqrt{2}$ (d) $\sqrt{2}$

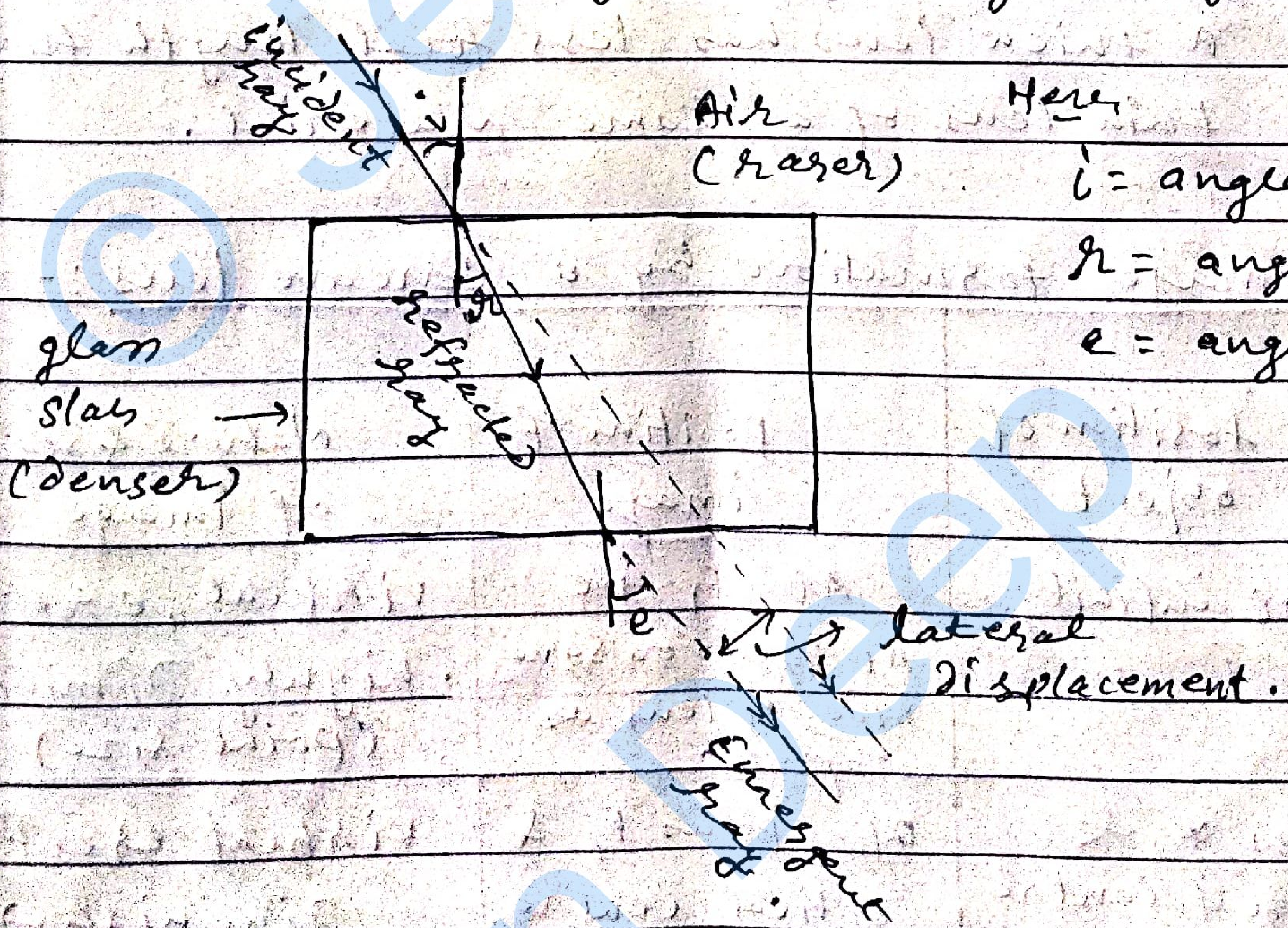


Here $i = 60°$
$r = 45°$

$$\because \frac{\mu_B}{\mu_A} = \frac{\sin i}{\sin r} \Rightarrow \frac{\mu_B}{\mu_A} = \frac{\sin 60°}{\sin 45°} = \frac{\frac{\sqrt{3}}{2}}{\frac{1}{\sqrt{2}}} = \frac{\sqrt{3}}{\sqrt{2}}$$

Correct option is (a).

Refraction through a rectangular glass slab :-



Here,
i = angle of incidence
r = angle of refraction
e = angle of emergence.

When a light ray enters into a glass slab, then the emergent ray is parallel to the incident ray

But it is shifted sideward slightly.

Lateral displacement: The perpendicular distance between the emergent ray & incident ray when the light passes out of a glass slab is called lateral displacement.

Lens:-

- Focal length of a lens implies the second focal length.
- Focal length of a lens depends on the refractive index of material of lens.
- If a lens is placed in water instead of air, its focal length increases.
- A thick lens has less focal length than a thin lens of a same material.

Image formation by a concave lens:-

Position of object	Position of image	Nature & Size of image.
At infinity.	At F_1 i.e At focus on same side of lens as object.	virtual, erect & highly diminished (point size)
B/w ∞ & optical centre O of the lens	B/w focus F_1 & optical centre O.	virtual erect & diminished.

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Image formation by a convex lens:-

position of object	position of image	Nature & size of image.
(i) At ∞	At F_2	Real, inverted & extremely diminished (point size)
(ii) Beyond $2F_1$	B/w F_2 & $2F_2$	Real inverted & diminished.
(iii) At $2F_1$	At $2F_2$	Real, inverted & of same size as that of object.
(iv) B/w F_1 & $2F_1$	Beyond $2F_2$	Real, inverted & enlarged.
(v) At F_1	At ∞	Real, inverted & highly enlarged.
(vi) B/w optical centre O & F_1	on the same side of the lens as the object.	virtual, erect & enlarged.

Applications of lenses:-

(i) we usually use spectacles when our eyesight weakens. they either consists of convex lens or concave lens or both.

(ii) in spectroscope - convex lens - for obtaining pure spectrum.

(iii) in telescope, camera, slide projector etc.

(iv) in magnifying glass - convex lens

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Lens formula:

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

Linear magnification:

$$m = \frac{h'}{h} = \frac{v}{u}$$

Where, u = object distance
v = Image distance.
f = focal length.

Power of a lens:-

The ability of a lens to deviate light rays towards or away from its principal axis is called power of lens.

it is defined as the reciprocal of the focal length in metres.

$$\text{power}(P) = \frac{1}{f(\text{in m})}$$

- The S.I unit of power of lens is dioptre (D).
- The power of convex lens is positive & that of concave lens is negative.
- if many thin lenses are in contact with each other, then the total power is the algebraic sum of powers of individual lenses

i.e $P = P_1 + P_2 + P_3 + \cdots\cdots$

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Q. A 5 cm tall object is placed perpendicular to the principal axis of a convex lens of a focal length 20 cm. The distance of the object from lens is 30 cm. Determine the – (i) position (ii) nature & (iii) size of image formed.

Soln:- (Hint) given, $h = 5$ cm

$f = +20$ cm

$u = -30$ cm

$h' = ??$

$v = ??$

Ans: (i) $v = 60$ cm

(ii) & (iii) – since $m = \frac{v}{u} = \frac{h'}{h} \Rightarrow h' = -10$ cm

(i.e. The image is real, inverted & magnified.)

Q. A concave lens has a focal length 15 cm. At what distance should an object be placed from the lens so that it forms an image at 10 cm from the lens? What is the nature of the image?

Soln:- given, $f = -15$ cm

$v = -10$ cm

$u = ??$

Acc to lens formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\therefore \frac{1}{-15} = \frac{1}{-10} - \frac{1}{u} \Rightarrow$ $\boxed{u = -30 \text{ cm}}$

Since it is a concave lens, the image is virtual, erect & diminished.

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Q) Define 1 dioptre of power of a lens.
Ans: 1 dioptre is the power of a lens whose focal length is 1 metre.

$$\boxed{1D = 1\,m^{-1}}$$

Q) Find the power of a concave lens of focal length 2m.

Soln: given $f = -2m$

$$\therefore P = \frac{1}{f(m)} = \frac{-1}{2} = -0.5\,D \quad \text{Ans.}$$

Q) A convergent lens of power 8D is combined with a divergent lens of power -10D. Calculate -
(i) power of combination &
(ii) focal length of combination.

Soln: given, $P_1 = 8D$
$P_2 = -10D$

$\therefore$ (i) power of combination

$$P = P_1 + P_2 = 8 - 10 = -2D \quad \text{Ans.}$$

(ii) focal length of combination:

$$f = \frac{1}{P} = \frac{1}{-2} = -0.5m$$
$$= -50\,cm \quad \text{Ans.}$$

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Human Eye & the Colourful world :-

Human Eye: it is roughly Spherical in Shape with a diameter of about 2.3 c.m . it Consists of a Convex lens made up of living tissues.

parts of a Human Eye:

(i) **Cornea** - light enters the eye through a thin membrane Called the Cornea. Most of the refraction of light rays entering the eye occurs at the outer Surface of Cornea.

(ii) Iris - it is a dark muscular diaphragm that controls the size of the pupil.
(iii) pupil - The pupil regulates & controls the amount of light entering the eye.
(iv) Retina - it is a delicate membrane having enormous number of light-sensitive cells. The eye lens forms an inverted real image of the object on the retina.
(v) Ciliary muscles : These muscles hold the eye lens in position, it's focal length can be adjusted by these ciliary muscles.

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power of Accommodation:

The ability of the eye lens to adjust its focal length ~~to~~ to focus on objects at different distances.

Defect of vision & their correction:

(i) Myopia
(ii) ~~Presbyopia~~ Hypermetropia
(iii) Presbyopia.

(i) Myopia or Near-Sightedness:

A person with myopia can see nearby objects clearly but cannot see distant objects distinctly.

Cause of Myopia:

This defect may arise due to –
(i) excessive curvature of the eye lens.
(ii) elongation of the eyeball.

Correction of Myopia:

This defect can be corrected by using a concave lens of suitable power.

O: far point of a myopic eye.

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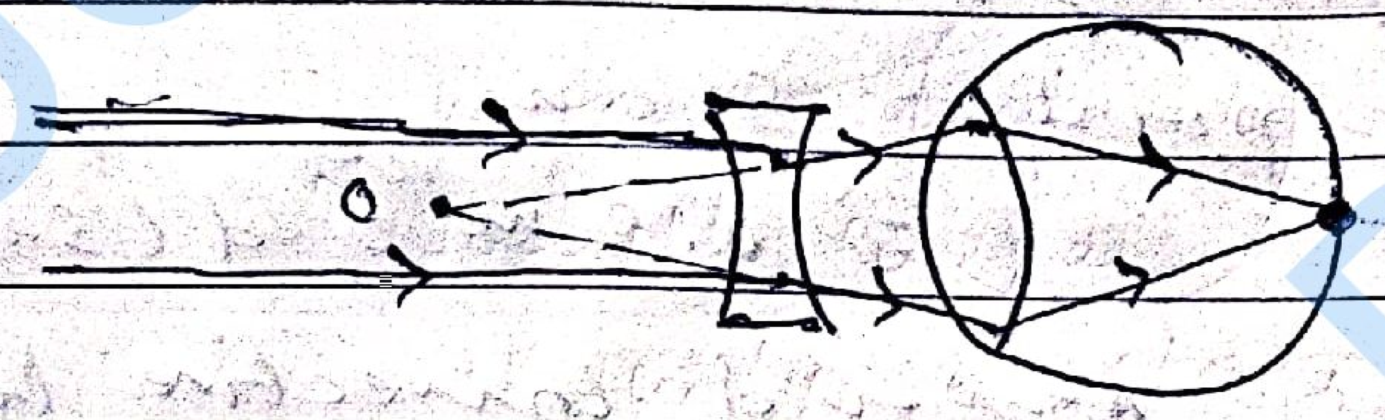
fig: Myopic eye



correction for Myopia.

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focal length & power of concave lens for correction of Myopia :-

Let far point of myopic eye be d, then we can write,

$u = -\infty$ (infinity)

$v = -d$ (far point)

$f = ?$

$P = ?$

Using lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\Rightarrow \frac{1}{-d} - \frac{1}{(-\infty)} = \frac{1}{f}$

$\Rightarrow -\frac{1}{d} = \frac{1}{f}$

$\Rightarrow \boxed{f = -d}$

$\Rightarrow$ i.e power of corrective lens will be $P = \frac{1}{f} = -\frac{1}{d}$

$\boxed{P = -\frac{1}{d}}$

i.e lens will be concave.

(Q) A far point of a myopic person is 80 c.m in front of the eye. what is nature & power of lens required to correct the problems?

Soln. for myopic eye,

far point = 80 c.m

= 0.8 m = d (say)

we know that, power of corrective lens for myopia will be

$$P = -\frac{1}{d} = -\frac{1}{0.8} = -\frac{10}{8} = -\frac{5}{4}\ D$$

$$= -1.25\ D$$

Negative sign indicate that corrective lens will be concave.

Hypermetropia or far-sightedness.

↳ A person with this defect can see distant object clearly but cannot see nearby object distinctly.

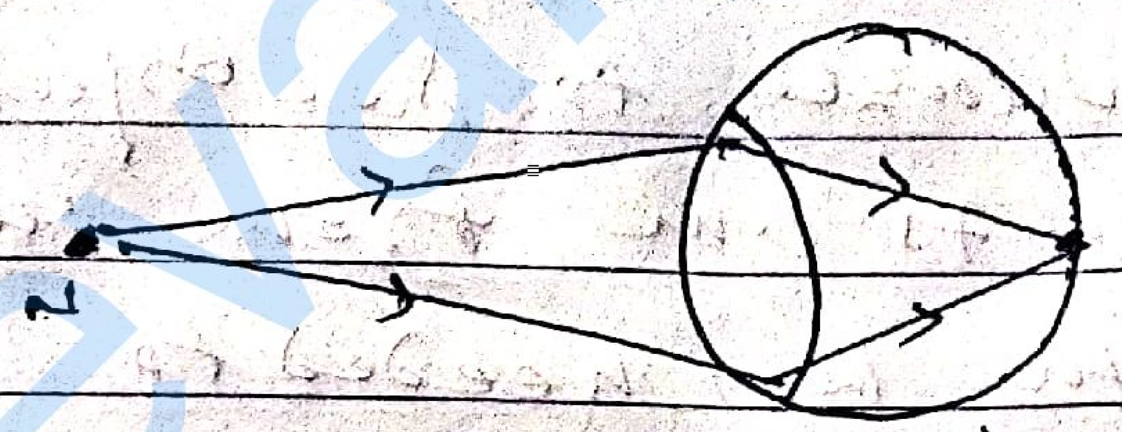
Cause of Hypermetropia –

The possible cause arises either because

(i) The focal length of the eye lens is too long.

(ii) The eyeball has become too small.

Correction: This defect can be corrected by using a convex lens of suitable power.



N : Near point of H/eye.

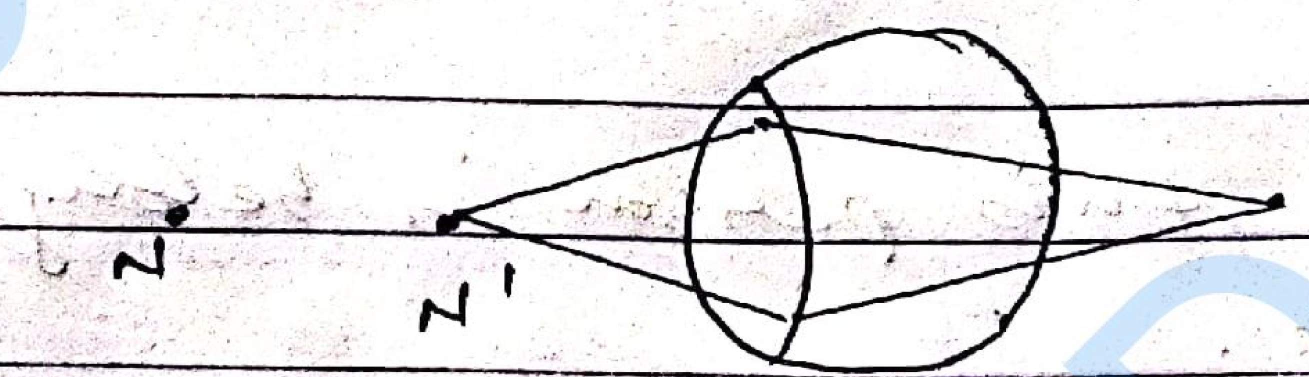
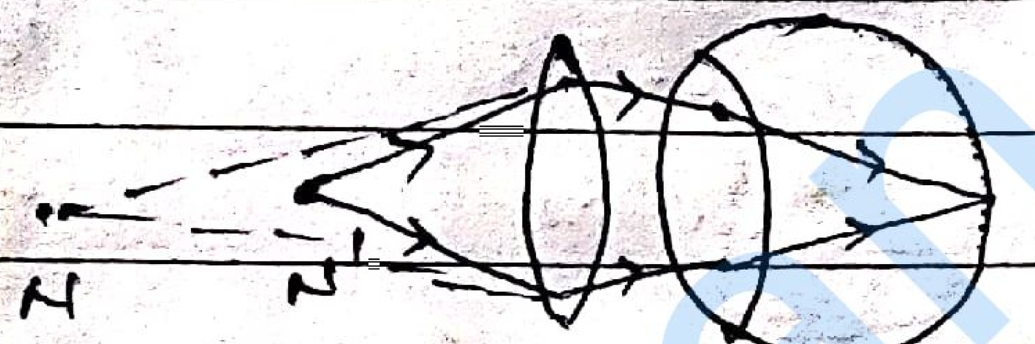


fig : Hypermetropic eye



correction for Hypermetropia.

__focal length & power of Convex lens for correction of Hypermetropia :-__

Let d = Near point of Hypermetropic eye.
D = LDDV = 25 c.m

for correction, we take,

$u = -25\text{ c.m} = \text{LDDV} = D$ (say)

$v = -d$ (Near point)

$f = ?$

Using len formula,

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

$$\frac{1}{-d} - \frac{1}{-D} = \frac{1}{f}$$

$$\frac{1}{f} = \frac{1}{D} - \frac{1}{d} = \frac{d-D}{Dd}$$

$$\boxed{P = \frac{d-D}{Dd}}$$

(Here $d > D$)

Here d & D must be in meter.

So, P is +ve, shows correction lens will be convex.

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Q. A person is unable to see objects distinctly placed within 75 c.m from this eye. Calculate the power of the lens needed to correct this defect.

Soln: Clearly, this person is belong from Hyper metropia.

So,

Let $d = 75cm$ (Near point) $= 0.75m$

$D = LDDV = 25 cm = 0.25m$

For correction, ~~we take~~ the power of lens will be $\frac{d-D}{Dd}$.

$$\Rightarrow p = \frac{d-D}{Dd} = \frac{0.75-0.25}{0.75\times0.25} = \frac{0.50}{0.75\times0.25}$$

$$p = \frac{2}{0.75} = \frac{200}{75} = +2.66 D$$

The sign indicate that corrective lens will be convex.

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-: Electricity :-

Charge: it is an intrinsic property of matter which is associated with the sub-atomic particle of the matter, which is defined by excess or deficiency of e^- on a body.

⇒ The S.I unit of electric charge : Coulomb (C)

⇒ quantisation of charge:

$$\boxed{q = \pm ne}$$

When n = No. of electron.

e = charge of one electron = 1.6×10^{-19} C.

i.e The total charge acquired by a body is an integral multiple of magnitude of charge on a single e^-. this principal is called quantisation of charge.

Electric current:

$$\boxed{I = \frac{q}{t} = \frac{ne}{t}} = \frac{\text{charge}}{\text{time}}$$

Define 1 Ampere:

if $q = 1C$

$t = 1$ sec. then

$$i = \frac{q}{t} = \frac{1}{1} = 1A.$$

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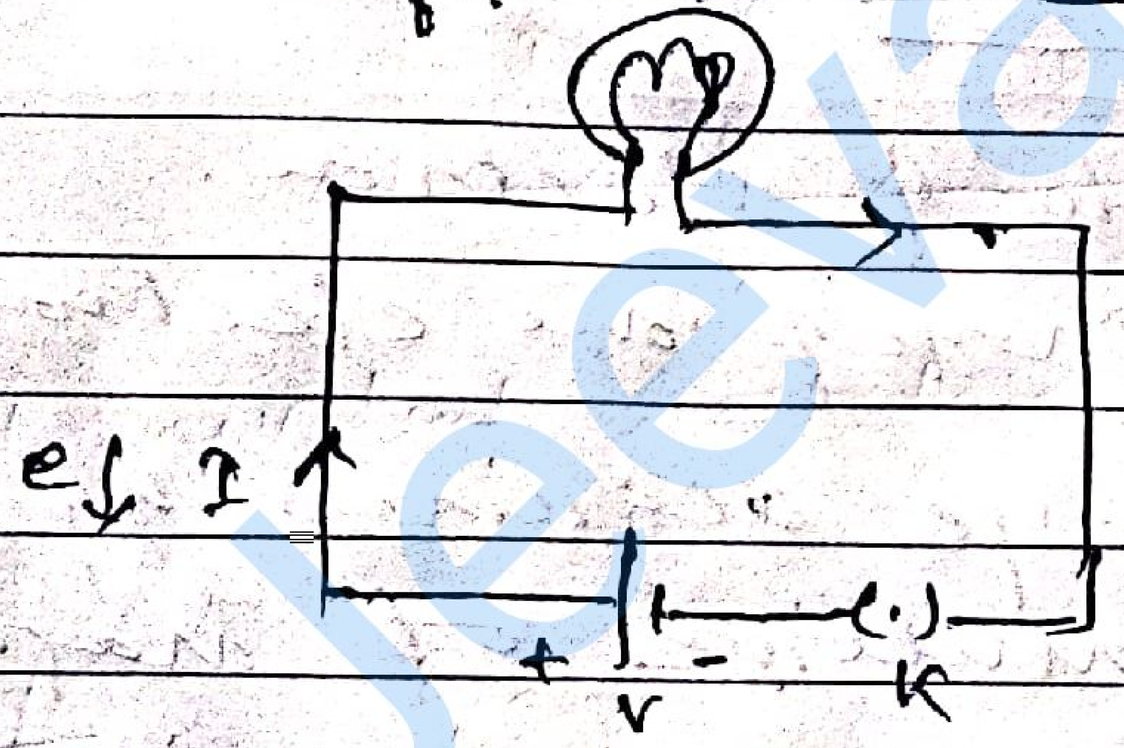
When 1 coulomb of charge flows through any cross-section of a conductor in one second, then the electric current ~~fl~~ flowing through it is said to be 1 ampere.

No. of electron in one Coulomb :

$$1\,C = 6.25 \times 10^{18} \text{ electron}$$

Dirn of Electric current :



⇒ Electric current is a scalar quantity which dirn is always conventional.

⇒ In an electric ckt. the ~~curr~~ current flows from positive terminal of the cell to the negative terminal.

⇒ dirn of electron : opposite to the dirn of conventional current.

Electric potential : $V = \frac{W}{q}$

Electric p.d , $\Delta V = V_B - V_A = \frac{W}{q}$

S.I unit of potential difference is volt (V).

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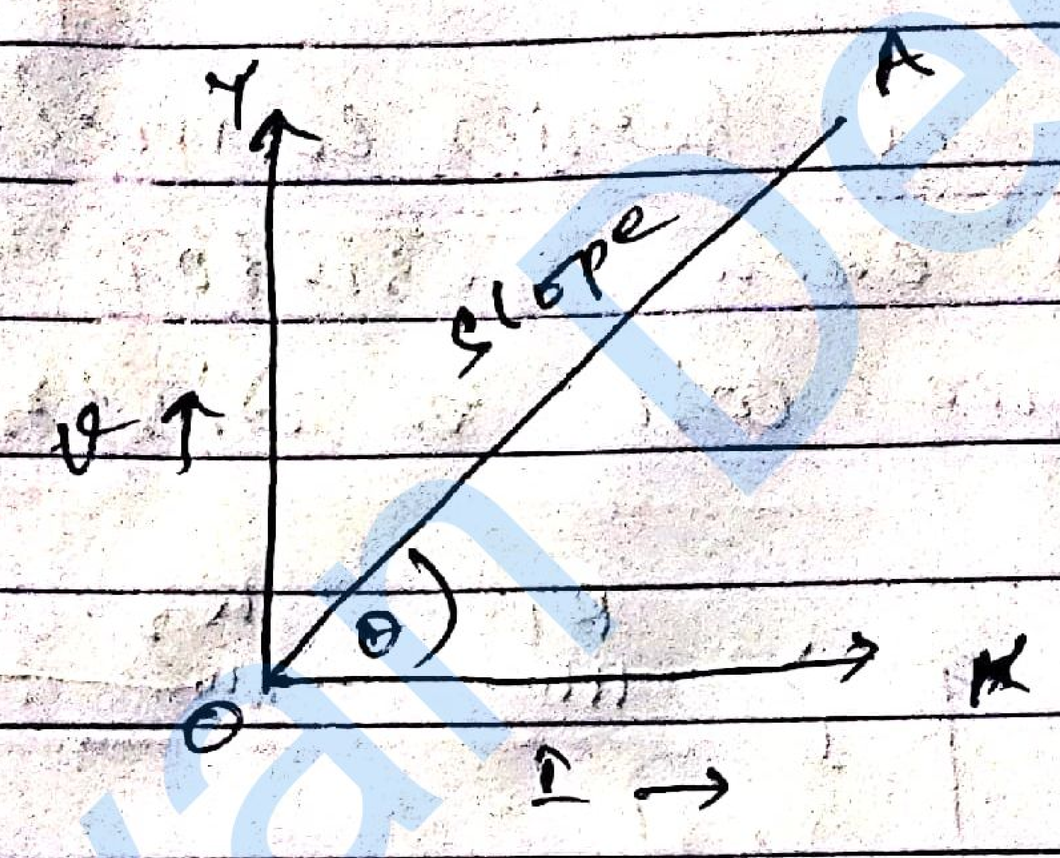
Ohm's law : $V \propto I$ (at constant temp.)

$$V = RI$$

or

$$R = \frac{V}{I}$$

V-I graph : (of ohmic conductor) :-



Resistance (R) $R = \frac{V}{I}$

S.I unit of Resistance is ohm (Ω).

conductance (G) : $G = \frac{1}{R}$

S.I unit of conductance : mho or ohm^{-1} (Ω^{-1}) or Siemen (S).

factor on which the resistance of a conductor depends :

$$R = \frac{\rho\, l}{A}$$

Specific resistance or resistivity (ρ) : Resistivity of a material doesn't depends on it's length or thickness or resistance. it depends only on the nature of material of conductor & temprature.

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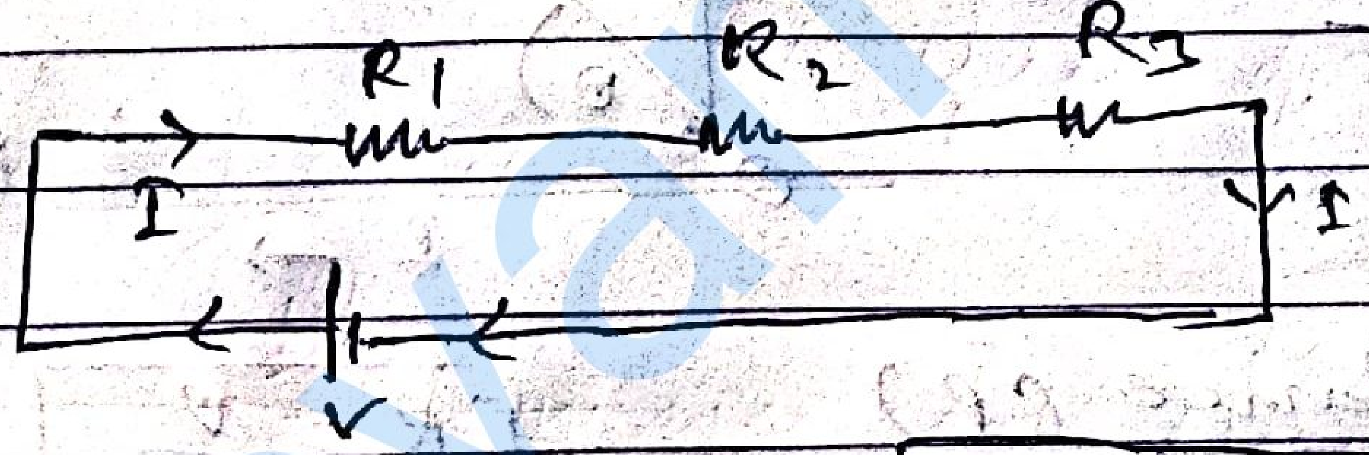
Grouping of Resistor

~~Resistor~~

- Series
- parallel.

Series: in series connection electric current across each resistor will be same. But potential difference will be distributed.

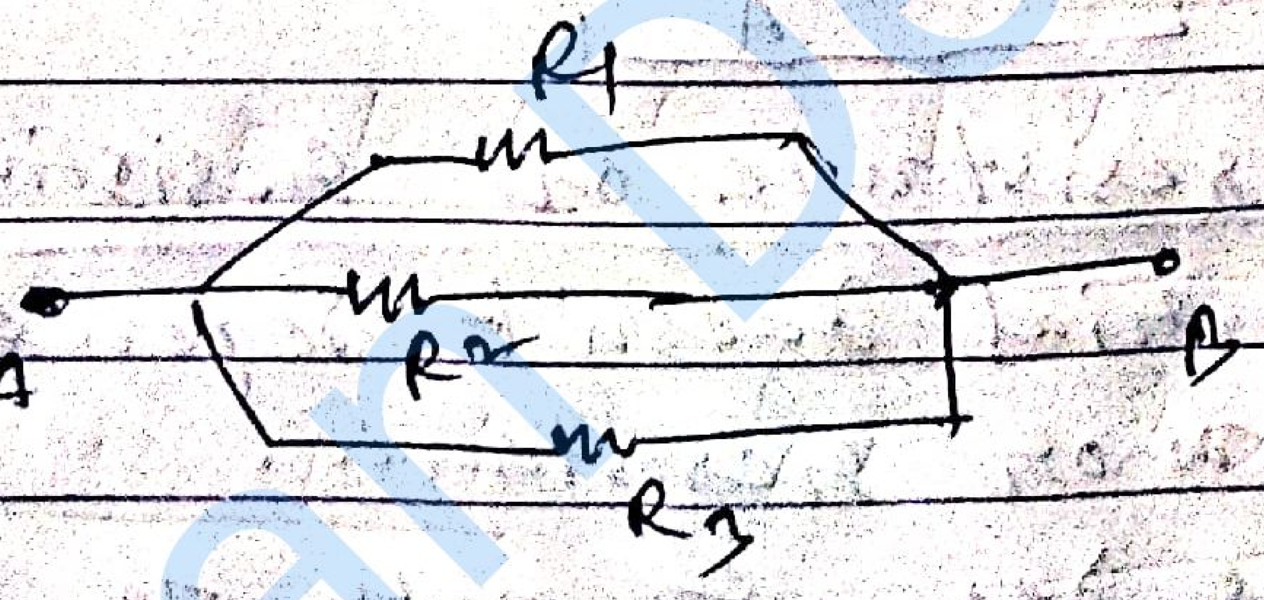


Equivalent Resistance $\boxed{R_{eq} = R_1 + R_2 + R_3}$

Note: for n identical resistor have resistance R their equivalent resistance will be nR.

i.e. $\boxed{R_{eq} = nR}$

parallel connection: in parallel connection electric current across each resistor will be distributed but p.d will be same.



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

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Note:-

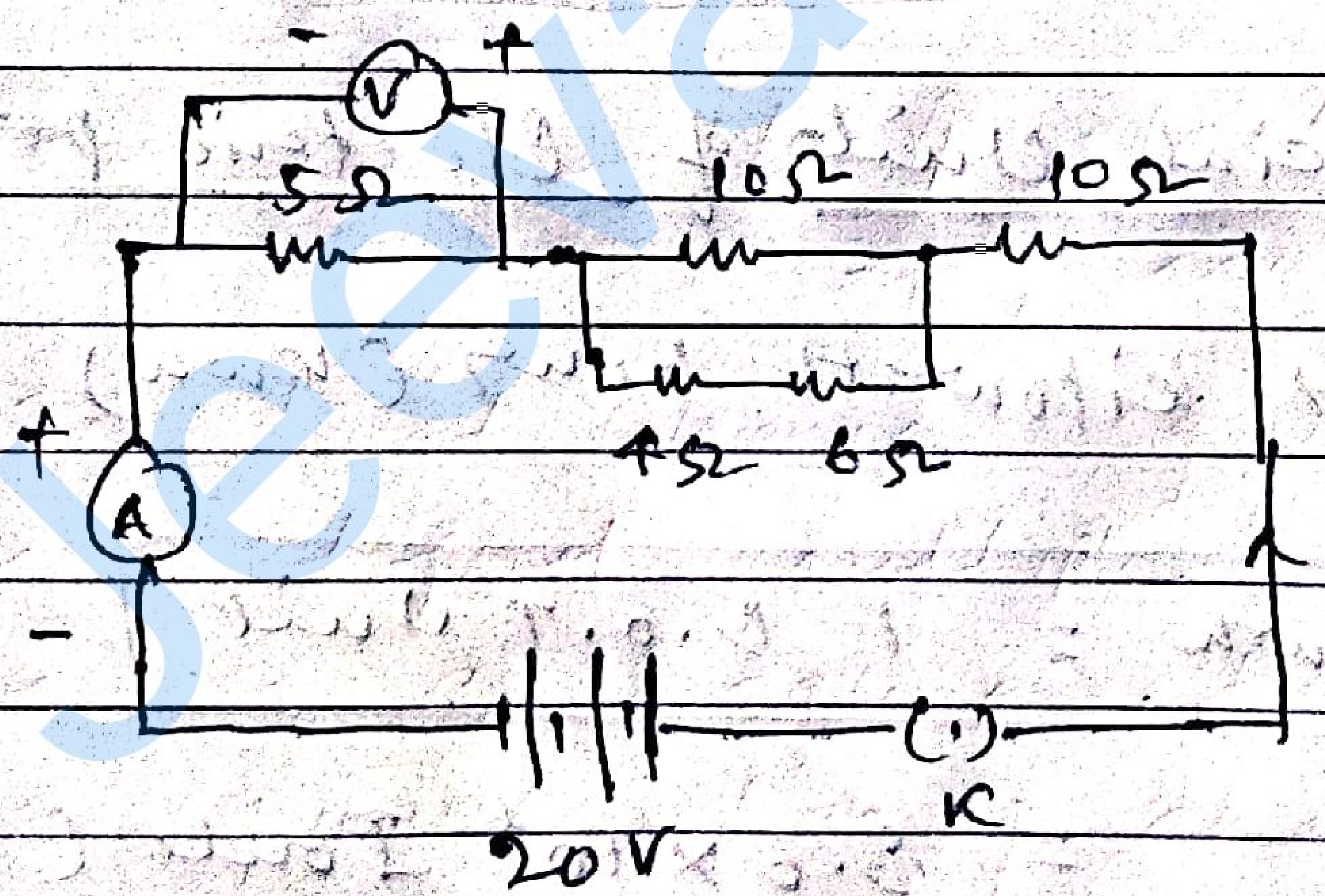
(i) for two resistor in parallel

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

(ii) for n identical resistor in parallel

$$R_{eq} = \frac{R}{n}$$

Q. Study the following ckt. & find :



(i) Effective resistance of the ckt.
(ii) current drawn from the battery
(iii) potential diff. across the 5Ω resistor.

Soln:

(i) $R_{s1} = 4 + 6 = 10\,\Omega$

$R_{p1} = \frac{10 \times 10}{10 + 10} = \frac{10 \times 10}{20} = 5\,\Omega$

Now Equivalent resistance

$= 5 + R_{p1} + 10 = 5 + 5 + 10 = 20\,\Omega$

(ii) $V = IR$

$I = V/R = \frac{20}{20} = 1\,A$.

(iii) $V = IR = 1 \times 5 = 5$ volt.

Heating effect of electric current

↳ $H = I^2Rt$

↳ Joule's law of heating.

Electric power : $P = VI$

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

The SI unit of electric power is watt (W).

Commercial unit of Electric ~~power~~ Energy

↳ kilowatt hour (kWh)

$1\ kWh = 1$ B.O.T unit

$= 3.6 \times 10^6$ Joule (J)

(Q.) if in a house everyday 5 bulb of 10 watt, 2 fan of 60 watt operates ~~about~~ 20 hour. then Calculate energy consumption of march month if per unit cost is Rs. 6.

Soln:

$E = n_1 P_1 t_1 + n_2 P_2 t_2$

$= 5 \times 10 \times 20 + 2 \times 60 \times 20$

$= 1000 + 2400$

$= 3400$ watthr/day.

Then total energy consumption of march

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month will be

$$E_{total} = 3400 \times 31 \text{ Wh}$$
$$= 105400 \text{ Wh.}$$
$$= \frac{105400}{1000} \text{ kWh.}$$
$$= 105.400 \text{ kWh.}$$

$$\text{Cost} = 105.400 \times 6$$
$$= £\ 632.4 \quad \text{A}_2 .$$

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