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Light

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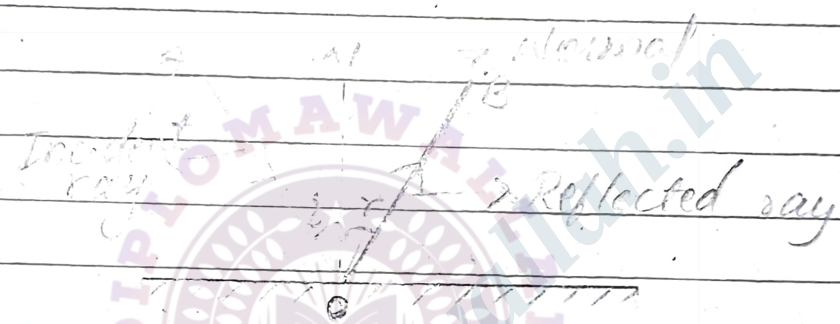
Reflection

The bouncing back of a ray of light when it falls on a reflecting surface such as mirror. It is observed that the light reflects in the same medium. This phenomenon is called reflection.



- Angle of incidence (i) = Angle made by incident ray with normal.
- Angle of reflection (r) = Angle made by reflected ray with normal.

* 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, reflected ray and the Normal all lies in the same plane.

NOTE:- If the angle of incidence is 0° then the reflected ray returns along the same path in which light is incident.

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REFRACTION

The phenomenon of bending or changing of direction of a ray of light from its original path when it passes from a transparent medium to another medium. This bending of light is called refraction.

* Laws of Refraction

i). The incident ray, refracted ray and Normal at the point of incidence all lie on the same plane.

ii). When light goes from one medium to another medium the frequency of light doesn't change. However, the velocity and wavelength of light change.

iii). The ratio of the sine of angle of incidence to the sine of angle of ~~reflection~~ is constant. This law is also known as Snell's law.

$$\boxed{\frac{\sin i}{\sin r} = \text{constant}} \Rightarrow \frac{\sin i}{\sin r} = \frac{1}{\mu_2} - \text{const}$$

The constant $(1/\mu_2)$ is called refractive index.

So, $\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$

$$\Rightarrow \boxed{\sin i \, \mu_1 = \sin r \, \mu_2}$$

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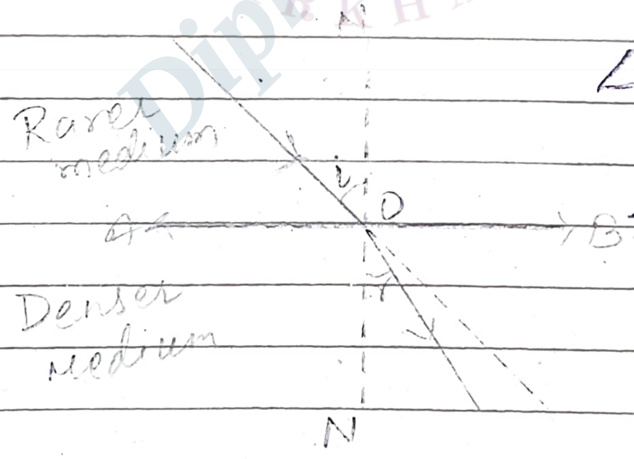
The refractive index of the medium is a measure of velocity of light in that medium. The Greater the refractive index of the medium the smaller is the velocity of light in that medium and vice-versa.

So, when:-

1. $v \uparrow$ $\mu \downarrow$ ⇒ optically rarer medium.
2. $v \downarrow$ $\mu \uparrow$ ⇒ optically denser medium.

Case I:- When light enters from air (rarer medium) into glass (denser medium) the ray of light bends toward the normal.



$\angle i > \angle r$

$$\frac{\sin i}{\sin r} > 1$$

Case II:- When the light enters from glass (denser) to air (rarer medium) the ray of light bends away from the normal.

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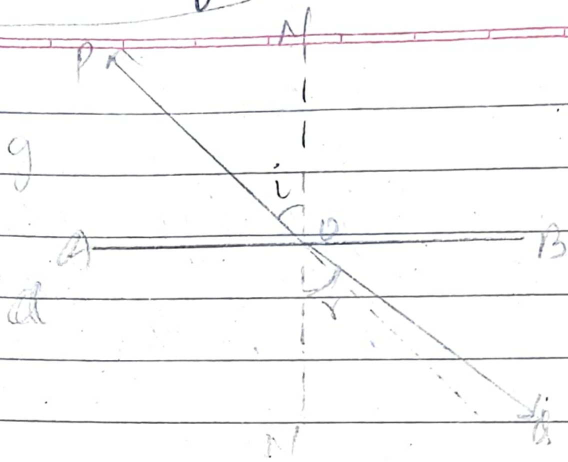
$$_g\mu_a = \frac{1}{_a\mu_g}$$

$i < r, \frac{\sin i}{\sin r} < 1$



$$_g\mu_a = \frac{1}{_a\mu_g}$$

$$_1\mu_2 = \frac{1}{_2\mu_1}$$

* Types of Refractive index

1. Absolute refractive index

The ratio of the velocity of light in vaccum (c) to the velocity of light in another medium (v).

$$\eta = \frac{\text{velocity of light in vaccum (c)}}{\text{velocity of light in another medium (v)}}$$

$$\boxed{\eta = \frac{c}{v}}$$

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Relative Refractive Index

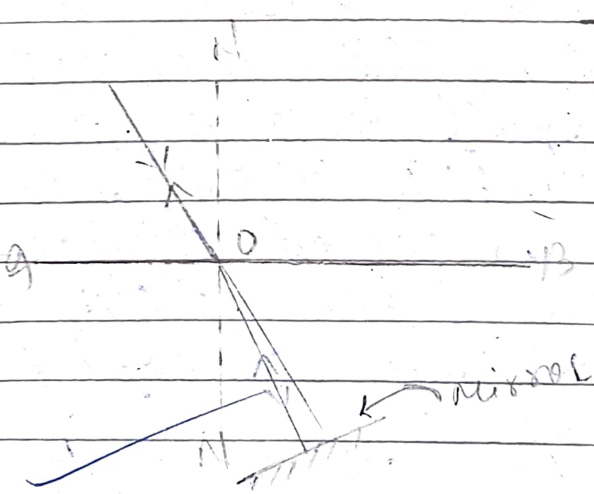
The ratio of the velocity of light in medium I to the velocity of light in medium II.

so,

$$\eta = \frac{\text{velocity of light in medium I}}{\text{velocity of light in medium II}}$$

Reversibility of Light

According to principle of reversibility of light, if a refracted ray is reversed in direction it will retraces its original path. If a plane mirror is placed normal to the path of refracted ray, then the ray is reversed in its ~~original~~ direction and retraces its original path.



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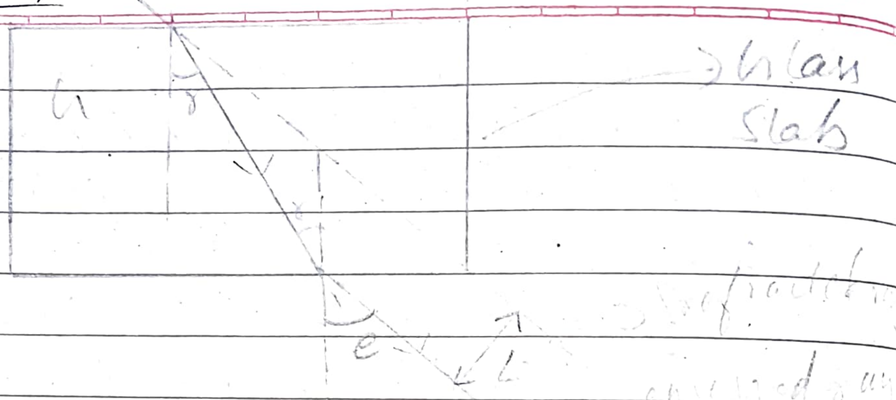
II Glass Slab



~~The Lateral displacement is the di~~
When a ray of light passes through a glass slap the emergent ray is ~~to~~ ∥ to the reflected ray and the distance btw them is called lateral displacement.

→ Factors affecting later displacement.

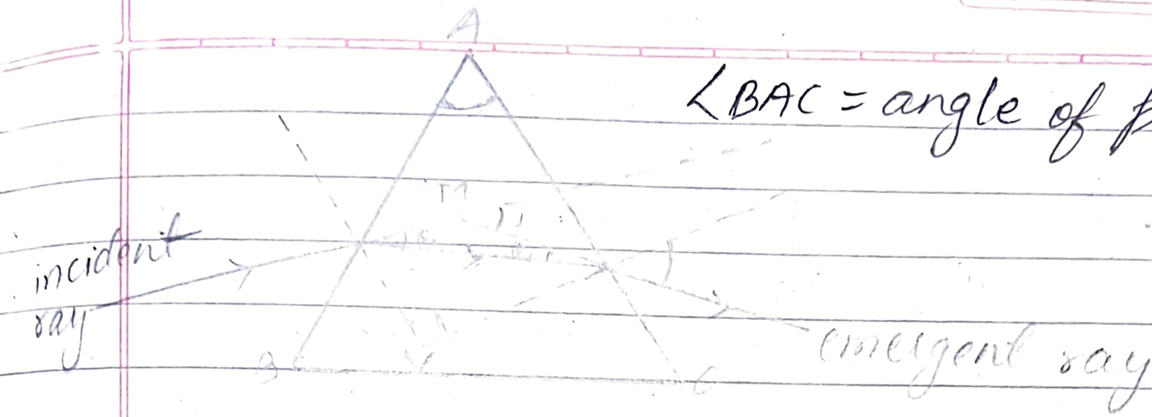
- $\angle i \uparrow$ L.D $\uparrow$
- $\eta \uparrow$ L.D $\uparrow$
- thickness $\uparrow$ L.D $\uparrow$
- $\lambda \downarrow$ L.D $\uparrow$

II Dispersion of Light

When a white light incident on the glass prism the emergent ray of light is split into its constituents seven colours (VIBGYOR). This phenomena is called dispersion of light. These seven colours collecting called spectrum of white light.

Minimum (Mean) deviation $= (\mu - 1) A$

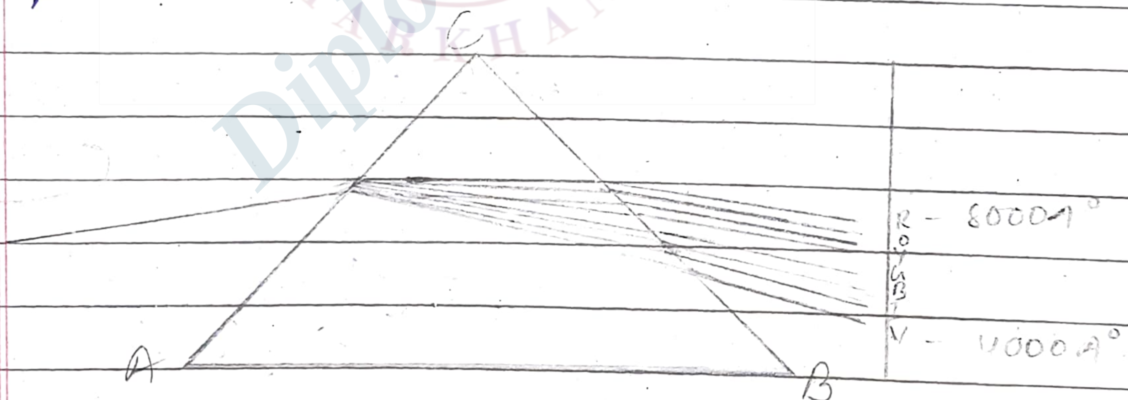
where, μ = refractive index
A = angle of prism

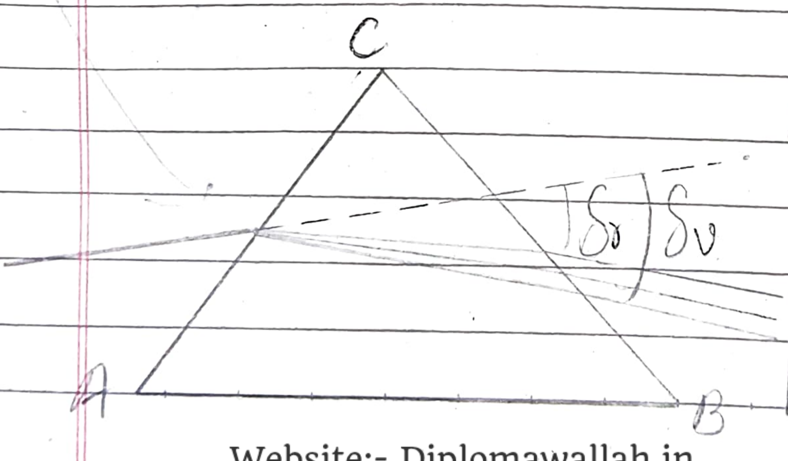


∠BAC = angle of prism

Angular dispersion

The angular separation between the two extreme colour i.e., Violet and Red, when a beam of white light is passed through a prism is called angular dispersion produced by the prism.





$$\delta_v - \delta_r = A(\mu_v - \mu_r)$$

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The angular dispersion = $\delta_v - \delta_r$

μ_r = Refractive index of prism material for red light
μ_v = Refractive index of prism material for violet light

deviation of violet = $\delta_v = A(\mu_v - 1)$
deviation of red = $\delta_r = A(\mu_r - 1)$

Dispersion Path

The dispersive power of a prism is the ratio of angular dispersion to the deviation of the mean ray (yellow) produced by the prism.

$$\text{Dispersive power } (\omega) = \frac{\text{Angular dispersion}}{\text{Mean deviation}}$$

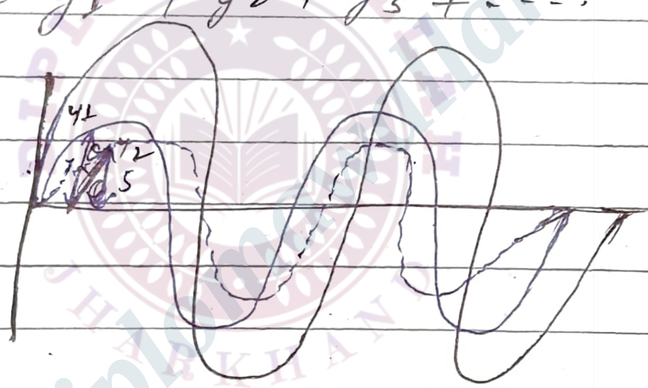
$$= \frac{A(\mu_v - \mu_r)}{A(\mu - 1)}$$

$$= \frac{(\mu_v - \mu_r)}{(\mu - 1)}$$

Superposition Principle of Waves

According to superposition principle, when two or more wave motions travelling through a medium superimpose one another, a new wave is formed in which resultant displacement ($\vec{y}$) at any instant is equal to the vector sum of the displacement due to individual waves ($\vec{y_1}, \vec{y_2}, \vec{y_3}, ----$) at that instants.

$$\vec{y} = \vec{y_1} + \vec{y_2} + \vec{y_3} + ----$$



Interference of Light :-

Interference of light is the phenomenon of redistribution of light energy in a medium on account of superposition of light waves from two coherent sources.

- The points, where the resultant intensity of light is maximum called as constructive interference.
- The points, where the resultant intensity of light is minimum called as destructive interference.

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Resultant intensity at P

Intensity at any point $\propto$ (Amplitude)^2

→ $I_0 \propto (a_0)^2$

The amplitude R of the resultant wave is $2a_0 \cos\frac{\phi}{2}$ therefore the resultant intensity light at P due to both slits is given by:-

$I_R \propto 4 a_0^2 \cos^2\phi/2$

$\frac{I_R}{I_0} = 4\cos^2\frac{\phi}{2}$ $(I_0 = a^2)$

$I_R = I_0\, 4\cos^2\phi/2$ — (iv)

Now,

Conditions for constructive and destructive interferences

$y_1 = a_0 \sin\omega t$

$y_2 = a_0 \sin(\omega t + \phi)$

$y = y_1 + y_2$

$= a_0 \sin\omega t + a_0 \sin(\omega t + \phi)$

$= a_0 \sin\omega t + a_0 \sin\omega t.\cos\phi + a_0 \sin\phi \cos\omega t$

$y = a_0 \sin\omega t(1 + \cos\phi) + a_0 \sin\phi \cos\omega t$

put $a_0(1 + \cos\phi) = R\cos\theta$ — (i)

$a_0 \sin\phi = R\sin\theta$ — (ii)

$y = a_0 \sin\omega t\, R\cos\theta + R\sin\theta \cdot \cos\omega t.$

$y = R\{\sin(\omega t + \phi)$ — (iii)

Adding (i) & (ii) and sq. both sides

$\Rightarrow R^2\cos^2\theta + R^2\sin^2\theta = a_0^2(1+\cos\phi)^2 + a_0^2\sin^2\phi$

$\Rightarrow R^2(\cos^2\theta + \sin^2\theta) = a_0^2(1+\cos^2\phi + 2\cos\phi) + a_0^2\sin^2\phi$

$\Rightarrow R^2 = a_0^2 + a_0^2\cos^2\phi + a_0^2\sin^2\phi + 2a_0^2\cos\phi$

$= a_0^2 + a_0^2(\cos^2\phi + \sin^2\phi) + 2a_0^2\cos\phi$

$= 2a_0^2 + 2a_0^2\cos\phi$

$= 2a_0^2(1+\cos\phi)$

$\Rightarrow R^2 = 2a_0^2\left(2\cos^2\frac{\phi}{2} + 1 - 1\right)$ $\{\cos 2\theta = 2\cos^2\theta - 1$, $\cos\frac{2\theta}{2} = 2\cos^2\frac{\theta}{2} - 1$

$\Rightarrow$ $$R^2 = 4a_0^2\cos^2\frac{\phi}{2}$$ — (iv)

* **For constructive interferences**

When constructive interferences occur at any point P the resultant intensity at the point is max. $I(4I_0\cos^2\frac{\phi}{2} = 1)$

$I = max$

$\cos\phi/2 = max.$

$\cos\phi = 1$ $\{\phi = 0, 2\pi, 4\pi, 6\pi, \dots\}$

$\phi = 2n\pi$, where, $n = 0, 1, 2, 3\dots$

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* **For destructive interference.**

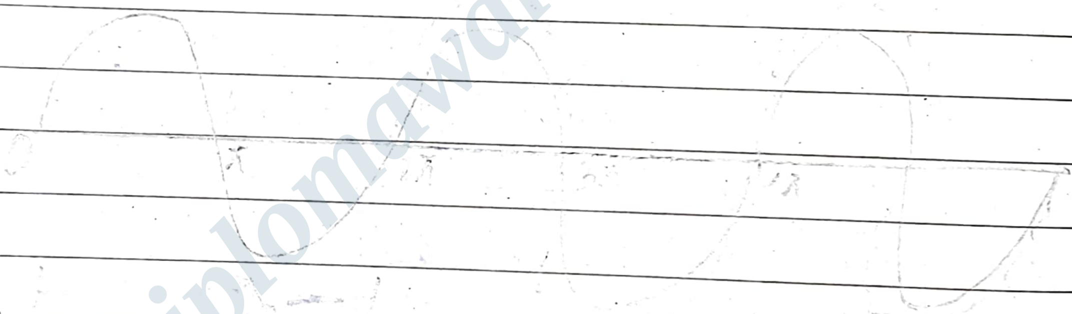
$I = min.$

$\cos\phi/2 = 0, \pi/2, 3\pi/2 \ldots$

$\cos\phi = -1 \quad \{\phi = 0, \pi, 3\pi, 5\pi \ldots\}$

so, $\phi = (2n-1)\pi$, where $n = 1, 2, 3 \ldots$

Relation between path difference and phase difference.



Phase diff → Path diff.

$2\pi \rightarrow \lambda$

$1 \rightarrow \frac{\lambda}{2\pi}$

$\phi \rightarrow \frac{\lambda}{2\pi}\phi \rightarrow \Delta x$

$$\Delta x = \frac{\lambda}{2\pi}\phi$$

- Path and phase diff for Constructive and destructive inferences

i). Constructive interferences

$$\Delta x = \frac{\lambda}{2\pi}\phi$$

$$\Delta x = \frac{\lambda}{2\pi} 2n\pi \quad (\phi = 2n\pi)$$

$$\boxed{\Delta x = n\lambda}, \quad n = 0, 1, 2, 3, 4 \ldots$$

(ii). Destructive interferences

$$\Delta x = \frac{\lambda}{2\pi}\phi$$

$$\Delta x = \frac{\lambda}{2\pi}(2n-1)\pi$$

$$\Delta x = (2n-1)\frac{\lambda}{2}, \quad n = 1, 2, 3, 4 \ldots$$

for, $n = 1$

$$\boxed{\Delta x = \frac{\lambda}{2}}$$

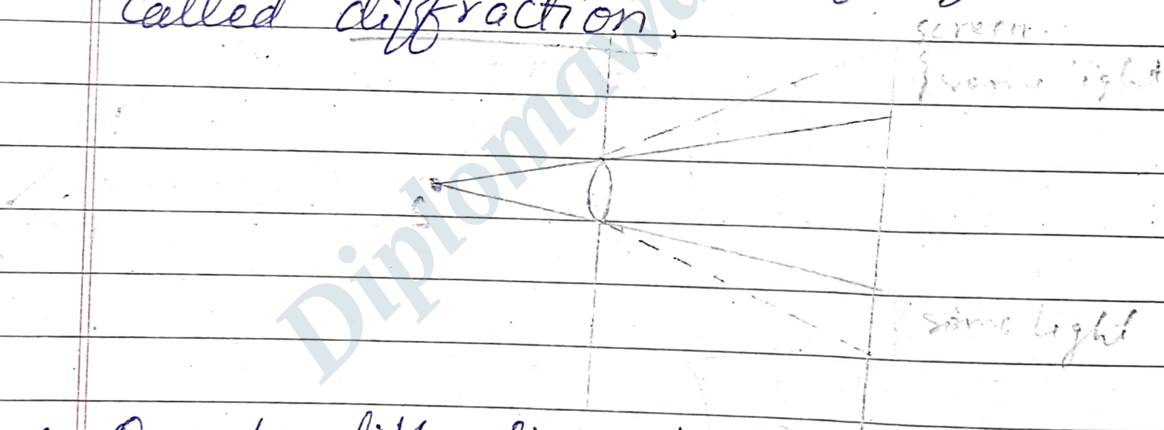
- **Coherent Sources:-**

The source of light which emit continuous light waves of the same wavelength, same frequency and in same phase or having a constant difference are called coherent sources.

- Two independent sources of light can't be coherent.
- Two coherent light sources can be obtained from a single source of light by reflection, refraction.

Diffraction

The phenomena of bending of light wave around corners of an obstacle or apperture in the path of light is called diffraction.



- Due to diffraction light enters in a shadow region.
- Diffraction becomes much more pronounced (much noticebale) the dimensions of the apperture are comparable to the wavelength of light.

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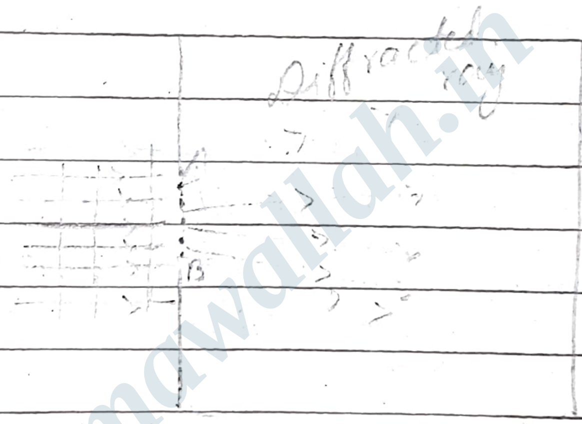
* Hugen Theory in Diffraction

- According to Huygen, all points on wave fronts (unblocked) act as source of new wave. This wave is called as diffracted wave
- Due to interference of these diffracted weave maximma & minimma obtained on a screen.



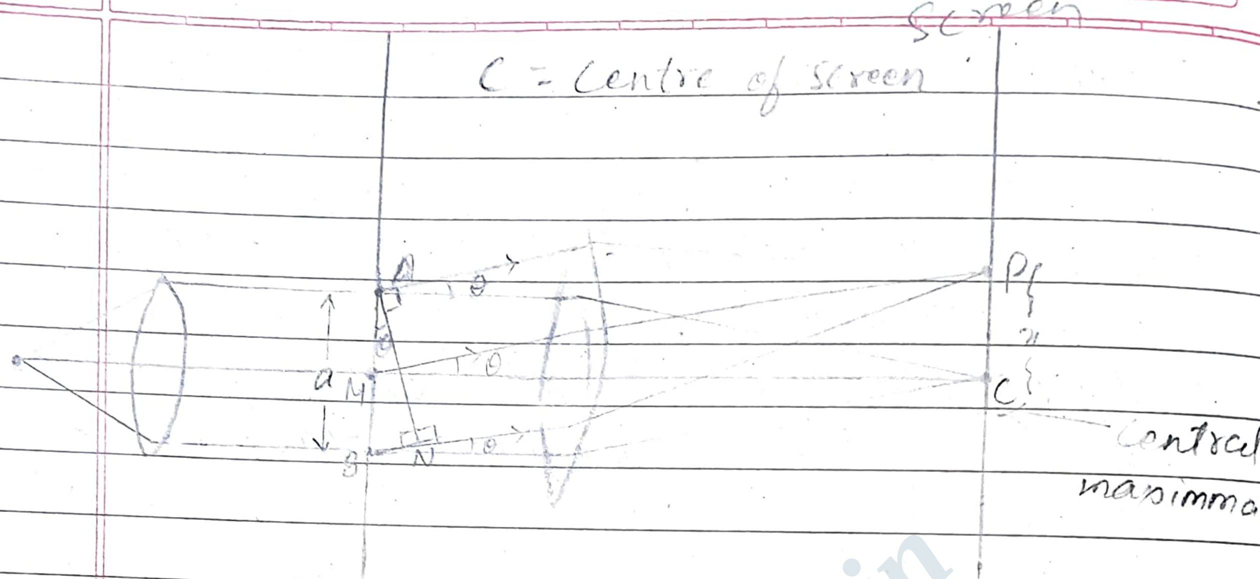
* TYPES OF DIFFRACTION

i). Fresnel's diffraction:- In this diffraction, source or screen or both at finite distance from obstacle / apperture.

ii). Fraunhofer diffraction:- In this diffraction sources & screen are at infinite distance from obstacle / apperture).

At C, path diff is 0.

C = Centre of screen



The path diff btw diffracted wave from A & B is equal to BN.

So, $\angle BAN = 90 - (90 - \theta)$
$= 90 - 90 + \theta$

So, In $\triangle ABN$ { AB = H, BN = P, AN = B

$\sin\theta = \frac{P}{H}$

$\sin\theta = \frac{BN}{a}$

$\boxed{BN = a\sin\theta}$

* Conditions for position of secondary minima

i) For 1st secondary minima

$\boxed{M\theta = \frac{\lambda}{2}}$

ii) For 2nd secondary minima

$a\sin\theta = 2\lambda \Rightarrow a\theta = \frac{\lambda}{2} \Rightarrow \theta = \frac{\lambda}{2}$

iii) For 3rd secondary and nth secondary minima

$a\sin\theta = 3\lambda \Rightarrow \boxed{\theta = \frac{3\lambda}{a}}$; $a\sin\theta = n\lambda$

$\boxed{\theta = n\lambda/a}$

IMPORTANT QUESTION'S

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1. What is Surface Tension? Give its dimension.

Ans→ The surface tension is the property of the particles of the liquid ~~to~~ that its free surface behaves like a stretched membrane and tries to occupy less area as possible. This property is known as surface tension.

- The molecules on the surface of the ~~liq~~ liquid have more potential energy than those within the liquid.

we know,

$$S \cdot T = \frac{F \text{ (Force)}}{l \text{ (Length)}}$$

$$S \cdot T = \frac{MLT^{-2}}{L}$$

$[F = MLT^{-2}, l = L]$

$$\boxed{S \cdot T = MT^{-2}}$$

2. Distinguish between Cohesive and adhesive force.

Ans→

Cohesive Force	Adhesive Force
• The force acting between the similar molecules of objects are called cohesive force.	• The force acting between the disimilar molecules of objects are called adhesive force.
• It is max. in solid.	• It is maximum in liquid and gas.
• E.g:- The molecules of water.	• E.g:- the ink stick to the paper.

3. Define coefficient of thermal conductivity? Give any four applications of thermal conductivity to everyday life.

Ans:- The coefficient of thermal conductivity is a measure of a material's ability to transfer heat through conduction, essentially indicating how readily heat flows through a material when a temperature difference exist across it; materials with high thermal conductivity transfer heat quickly, while thoere with low conductivity transfer heat slowly.

The four applications related to daily life:-

i). The transfer of heat to utensils during cooking food.

ii). The transfer of heat from iron to shirt while pressing the shirt.

iii). The pouring of hot tea in a cup also warm the cup.

iv). A metal spoon in a hot cup of tea.

4. Explain Stoke's law. Also define terminal velocity.

Ans:- The stoke's law states that the force that retards a spherical body of

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radius 'r' moving at a velocity 'v' through a viscous fluid is directly proportional to the viscous drag force experience.

$F_{(d)} = 6\pi r v \eta$ $\{K = 6\pi\}$

$F \propto r$, $F \propto v$, $F \propto \eta$

$F \propto r v \eta$

$F = K r v \eta$

~~$F = 6\pi r v \eta$~~ (

Terminal velocity :- The maximum const. velocity aquired by a body while falling freely through a viscous medium is called terminal velocity.

Q. Write the physical significance of refractive index.

Ans. The physical significance of the refractive index that how much the light bends or slow down when it travels from one medium to another. This phenomenon is also known as refraction. The more refractive index means light travel slower in that medium and bend more.

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6. Differences between the diffrent modes of heat.

Ans→ ~~Con~~ There are three different modes of heat are as follows :-

1. Conduction

- It is process in which the transfer of heat takes place through direct contact between the particles of a substance, without the movement of the particles of substances.
- It occurs mainly in solids, especially metals, which are good conductor of heat.
- Eg:- A metal rod get hot when one end is placed in a flame.

2. Convection

- It is the process in which the heat is transmitted through the actual movement of particles of fluid (liquid or gases).
- It occurs mainly in liquid and gases but not in solids because they do not flow.
- Eg:- water boiling in a pot (hot water rises, cool water sinks).

Eg:- wind and ocean current (hot air rises, cool air moves in).

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3. <u>Radiation</u>
It is process in which the transfer of heat in the form of electromagnetic waves, without needing a medium (it can through space).

- Eg:- Heat from the Sun warming the Earth.
- A Campfire warming people sitting around it.
- Infrared heaters warming a room.

1. What is the cause of refraction.
2. What is dispersion of light. Explain with ray diagram.
3. State law's of refraction, show that the emergent ray from glas slab is parallel to the indicident ray.
4. What is the total internal Reflection. Explain the condition for the phenomenon.
5. A thin prism of 60° angle gives a deviation of 3°, find the refractive index of the material of prism.

1 m = 10

$10^1 \times 10^{-4}$

10

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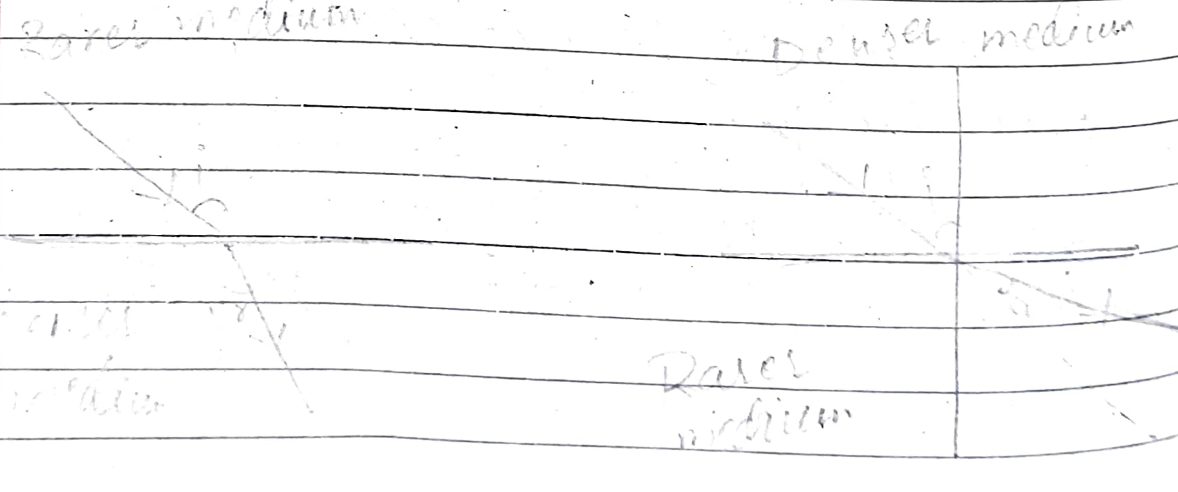
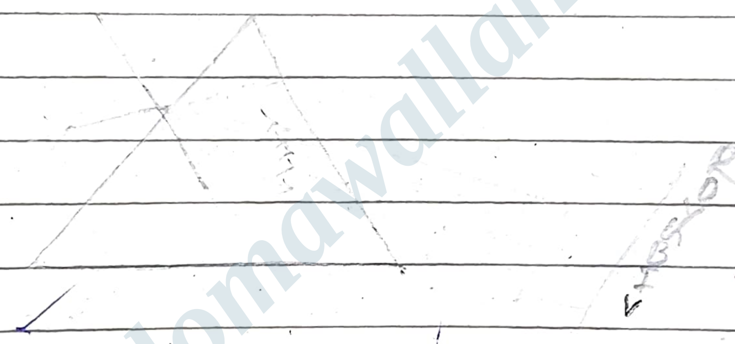
1. Ans: The refraction occurs due to change in speed of light in different medium due to different optical density of the medium.

The main causes of refractions are:-

- Change in speed:- light travels with different speeds in different materials.
- Change in medium:- when light travels in higher refractive index medium causes it bends toward the normal. While, the medium of lower refractive index the light ray passes away from the normal.
- Difference in optical density:- The more optical denser medium leads to more bending of light ray and vice-versa.



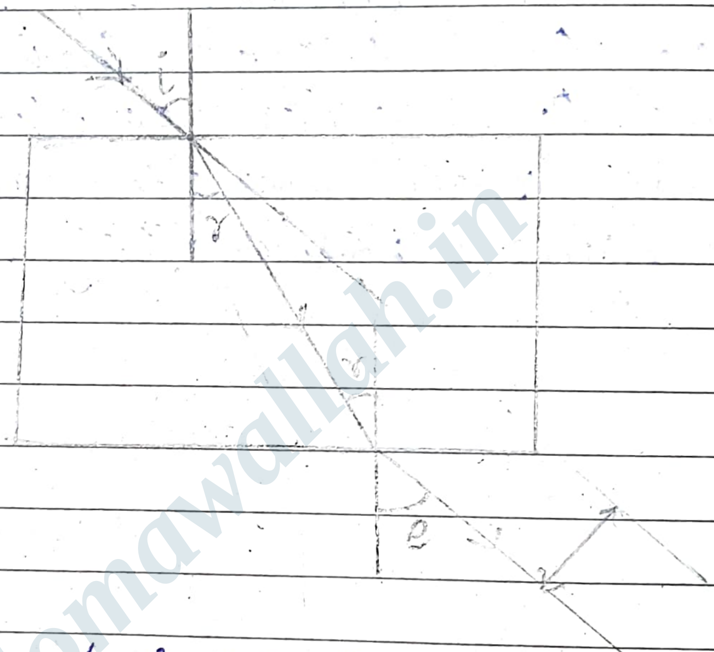
2. The splitting of white light when it travels in a glass prism it splits into its constituents seven colours (VIBGYOR). This phenomenon is know dispersion of light.
Red and violet have more wavelength and O smaller wavelength that causes ~~more~~ less bending and ~~less~~ more bending of light respectively.



3. The following are the laws of refraction are as follows:-
i). The incident ray, the refracted ray and the Normal all lie in the same plane at the point of incidence.
ii). When light goes from one medium to another the frequency of light doesn't change. While, the wavelength and velocity of light get changed.
iii). The ratio of the sine of angle of incidence to the sine of angle of refraction is ~~same~~ constant for all media.

This law is also known as snell's law.

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



When a ray of light passes through a glass the incident ray is parallel to the emergent ray. This is the // distance between them as called lateral displacement.

4. The Total Internal Reflection is an optical phenomenon that occurs when a light ray travelling from a denser to a rarer medium is completely reflected back into the denser medium instead of being refracted into the rarer medium.

→ **The Conditions for Total Internal Reflection :-**

i). The light ray must be travel from a denser medium to a rarer (Less denser) medium.

ii). The angle of incidence must be greater than the critical angle for the two media. The Critical angle is the angle of incidence at which the angle of refraction is 90° in the denser medium.

S: Angle of prism $= 60^\circ$
Minimum deviation $= 3^\circ$
To Find :- Refractive index
$\mu =$ refractive index
A = angle of prism

So,
Minimum deviation $= (\mu - 1) A$

$$3^\circ = (\mu - 1)\, 60^\circ$$

$$\frac{1}{20} = (\mu - 1)$$

$$0.05 = \mu - 1$$

$$\boxed{\mu = 1.05}$$

So,
Required refractive index is 1.05.