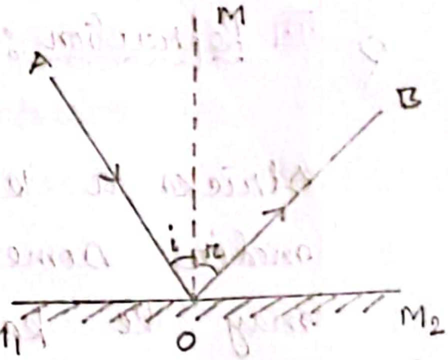
Geometrical optics

Reflection:



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When a light beam stricks a boundary between two media, some or all of the light may be returned back into first media. This phenomenon is called reflection of light.

AO → incident of light.
OB → reflected ray of the light.
MO → Normal.
M_1OM_2 → reflecting edge किनारा
i → angle of incidence
r → angle of reflection.

Laws of reflection:

1) 1st law: The incident ray, reflecting ray and the normal lie in the same plane.

2) Second law: The angle of incidence is equal to the angle of reflection ($\angle i = \angle r$).

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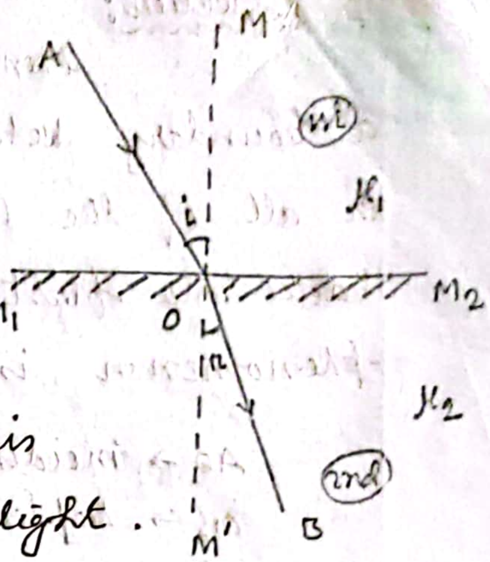
Refraction :

When a light beam strikes a boundary between two media some or all of the light may be pass into second medium with a change in the direction of propagation. this process is called refraction of light.



Laws of refraction :

1) 1st law : The incident ray, the refracted ray and the normal to the surface of separation at the point of incidence are coplaner.

2) 2nd law : The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant.

$$\mu_1 \sin i = \mu_2 \sin r$$

Snell's law, $\frac{\sin i}{\sin r}$ = constant.

Refractive index (μ):

It is defined as the ratio between the velocity of light in a vacuum (c) and the velocity of light in the medium.

$$\mu = \frac{c}{v}$$

$$c = n\lambda$$

$$v = n\lambda_m$$

$$\therefore \mu = \frac{n\lambda}{n\lambda_m}$$

$$\text{or, } \mu = \frac{\lambda}{\lambda_m}$$

λ = Wave length in vacuum.

λ_m = Wave length in medium.

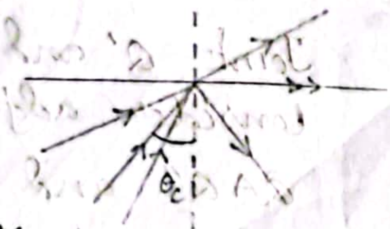
When light is propagated from one medium to another, the frequency remains constant. Wave length is different for different medium.

Optical path: 05

It is defined as the product of the geometrical distance and refractive index of the medium. ~~optical path~~. Let a ray travels a distance x in a medium of refractive index μ. Then the optical path is equal to μx.

Critical angle:

When incident ray approch an angle of 90° with normal there. reflected ray approach at a fixed angle θ_c beyond no refracted light is possible. The particular angle θ_c for which $\theta_r = 90°$ is called critical angle.



Fermat's principle states that the path followed by a ray of light in moving from one point to another point after any number of reflection or refraction, would always be stationary.

Totally internally reflection : 06

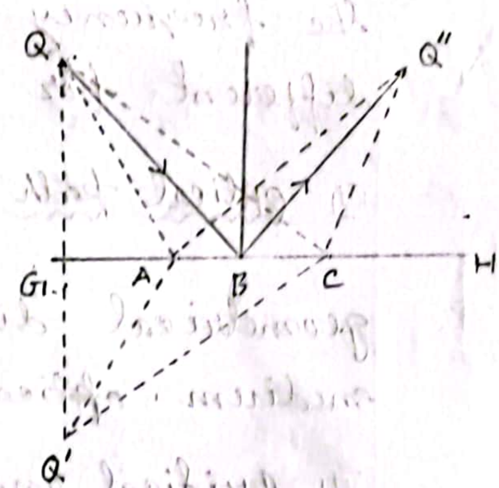
If the angle of incidence (θ) is greater than critical angle the instead of refraction its occur totally internally reflection.

state and explain Fermat's principle.

Fermat's principle of stationary time : 07+05

In 1658, Fermat enunciated the principle of least time for the path followed by light radiations.

"A light ray travelling from one point to another will follow a path such that compared with nearly paths, the time required is either a minimum or a maximum or will remain unchanged".



Explain: Ray of light came from 1st point Q then after reflected on a plane surface GH go to 2nd point Q" to get real paths, draw perpendicular and extened equal distance on other side

$$QG = GQ'$$

Joint Q' and Q"

Consider adjacent path at point A and C.

QAQ" and QCQ" is greater than QBQ".

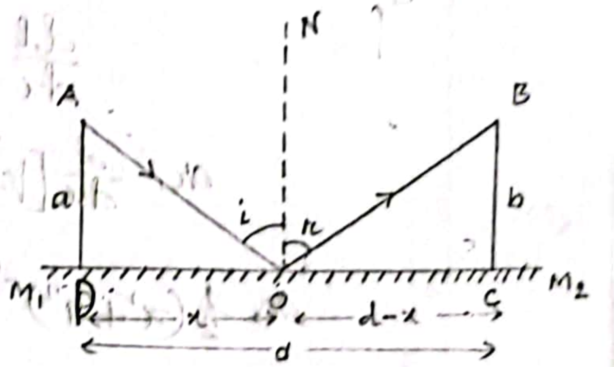
$QA = Q'A$ and $QC = Q'C$

$QAQ'' > QBQ''$ and $QCQ'' > QBQ''$

The real path QBQ" is minimum.

⊞ Law of reflection using Fermat's principle : 07+05

⇒ M_1M_2 be the plane mirror.



AO be the incident ray and the OB reflected ray. ON be the Normal. The angle of incidence is i and the angle of reflection is r.

$\therefore$ $CD = d$, $DO = x$, $OC = (d-x)$

$AD = a$, $BC = b$.

From ΔAOD,

$$OA^2 = OD^2 + AD^2$$

$$\text{or, } OA = \sqrt{OD^2 + AD^2}$$

$$= \sqrt{x^2 + a^2}$$

From ΔBOC, $OB^2 = OC^2 + BC^2$

$$\text{or, } OB = \sqrt{OC^2 + BC^2}$$

$$= \sqrt{(d-x)^2 + b^2}$$

Total length of the ray,

$$l = AO + OB.$$

$$= \sqrt{x^2 + a^2} + \sqrt{(d-x)^2 + b^2}$$

According to Fermat's principle, O will have a position such that the time of travel of the

Light must be minimum.

$$\frac{dl}{dx} = 0$$

$$\text{or, } \frac{d}{dx}\left[\sqrt{x^2+a^2} + \sqrt{(d-x)^2+b^2}\right] = 0$$

$$\text{or, } \frac{1}{2}(x^2+a^2)^{-1/2} \cdot 2x + \frac{1}{2}\left[\{(d-x)^2+b^2\}^{-1/2} \cdot 2(d-x)(-1)\right] = 0$$

$$\text{or, } \frac{x}{\sqrt{x^2+a^2}} - \frac{(d-x)}{\sqrt{(d-x)^2+b^2}} = 0$$

$$\text{or, } \frac{x}{\sqrt{x^2+a^2}} = \frac{d-x}{\sqrt{(d-x)^2+b^2}}$$

$$\text{or, } \frac{OD}{OA} = \frac{OC}{OB}$$

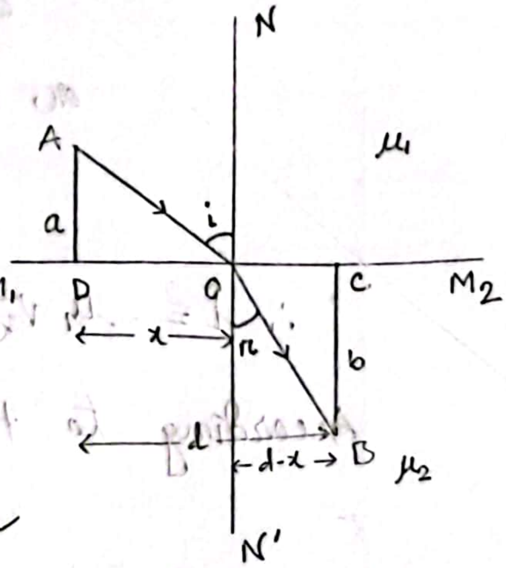
$$\text{or, } \sin i = \sin r$$

$$\text{or, } i = r$$

The angle of incidence is equal to the angle of reflection and the incident ray, reflection ray and normal lie in the same plane.

☐ Law of refraction using Fermat's principle : 07+05

⇒ Let, M_1M_2 is the boundary separating the two media of refractive indices μ_1 and μ_2. AO incident ray and OB be the refracted ray. NON' be the normal. The angle of incidence is i and the angle of refraction is r.



Here, $CD = d$, $DO = x$, $OC = (d-x)$

$AD = a$, $BC = b$.

Velocity of light = c.

Time taken along path AOB.

$$t = \frac{l_1}{v_1} + \frac{l_2}{v_2}$$

$$= \frac{l_1}{c/\mu_1} + \frac{l_2}{c/\mu_2} \quad [\because \mu = \frac{c}{v}]$$

$$= \frac{l_1\mu_1}{c} + \frac{l_2\mu_2}{c}$$

$$= \frac{1}{c}(l_1\mu_1 + l_2\mu_2).$$

$$= \frac{l}{c} \quad \text{where } l = l_1\mu_1 + l_2\mu_2 = \text{optical path}.$$

From ΔAOD, $OA^2 = OD^2 + AD^2$

as $OA = \sqrt{OD^2 + AD^2}$

$= \sqrt{x^2 + a^2}$

From ΔBOC, $OB^2 = OC^2 + BC^2$

or, $OB = \sqrt{OC^2 + BC^2}$

$= \sqrt{(d-x)^2 + b^2}$

$\therefore l = \mu_1 \sqrt{x^2+a^2} + \mu_2\sqrt{(d-x)^2 + b^2}$

According to Fermat's principle,

$$\frac{dl}{dx} = 0$$

or, $\frac{d}{dx}\left[\mu_1 \sqrt{x^2+a^2} + \mu_2\sqrt{(d-x)^2+b^2}\right] = 0$

or, $\mu_1 \frac{1}{2}(x^2+a^2)^{-1/2} \cdot 2x + \mu_2 \frac{1}{2}\left[\{(d-x)^2 + b^2\}^{-1/2} \cdot 2(d-x)(-1)\right] = 0$

or, $\frac{\mu_1 x}{\sqrt{x^2+a^2}} - \frac{\mu_2(d-x)}{\sqrt{(d-x)^2+b^2}} = 0$

or, $\frac{\mu_1 x}{\sqrt{x^2+a^2}} = \frac{\mu_2 (d-x)}{\sqrt{(d-x)^2+b^2}}$

or, $\mu_1 \sin i = \mu_2 \sin r$

Snell's law.

OR Derive Snell's law of refraction from Fermat's principle.

[7] Prob: An incident ray of wave length 4500 Å in air and plane surface of quartz and make angle 30° with normal. If the refractive index of quartz with respect to air is 1.466. Find the angle of refraction.

Soln: Here, The angle of incidence, $i = 30°$.

Refractive index of air, $\mu_1 = 1.003$

Refractive index of quartz, $\mu_2 = 1.466$.

and, the angle of refraction, $r = ?$.

We know,

$$\mu_1 \sin i = \mu_2 \sin r$$

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

$$= \boxed{\frac{1.466}{1.003} \sin 30°} = \frac{1.003}{1.466} \sin 30°$$

$$= 0.341166.$$

$$\text{or, } r = \sin^{-1}(0.341166).$$

$$\text{or, } r = 19.94°.$$

Ans

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06.10.09

Optics deals with production emission and propagation of light. Its nature and study of the phenomena of interference, difraction and polaraization is called physical optics.

Newton's corpuscular theory: 03+04

Light consists of a stream of particles is called corpuscles. These corpuscles come out by light and travel in straight line with large velocity.

"A luminous body continously emits tiny light and elastic particles called corpuscles in all directions they can travel through the interesties of the particles of matter with velocity of light. and they passes the property of reflection. When these particles fall on the retina of the eye, they produce the sensation of vission".

Origin of wave theory:

In 1679 Huggen's proposed the wave theory of light.

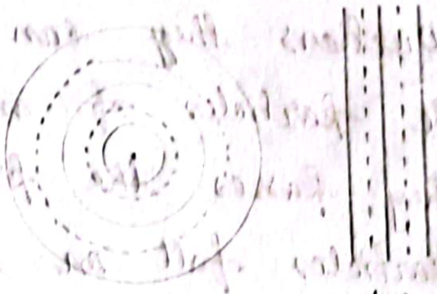
"The luminous body is a source of disturbance in a hypathetical medium called ether i.e space. The disturbance from source is propagated in the form of waves through space and the energy is distributed equally in all direction".

He also proposed that light wave to be longitudinal i.e vibration of particles is parallel to the direction of propagation of the wave.
Huygen's explaned reflection, refraction, double refraction but polarization could not explain.

Q Wave front : 03+07+07

Wave front is defined as, the locus of all the points of the medium which are vibrating in phase and are also displaced at the same time.

If the distance of source is small, the wave front (a).
If source is at large distance. Wave front is plane (b).

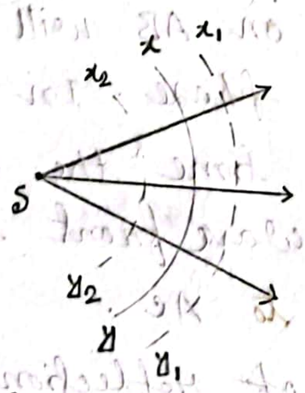


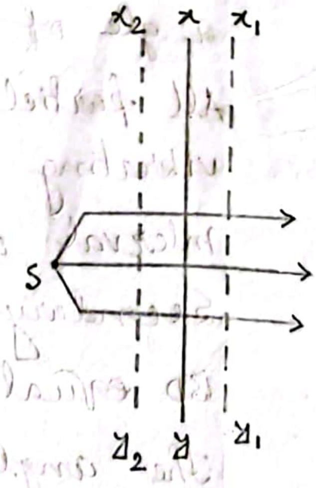
Production/
Example : i) When we drop a small stone in a pool of water circular ripples spread out from the point of stone (locus) each point of circles oscillates with same amplitude and same phase thus a circular wave front.

2) Plane wave front.

Huygen's principle : 04+06+08

"Each point of wave front is a source of secondary disturbance and the wavelets emanating from these points spread out in all directions with the speed of the wave. The envelope of these wavelets gives the shape of the new wavefront".





Explanation: S be the source of light emege in the form of waves. After an interval of time t, all particles of medium on the surface xy vibrates in phase.

xy is portion of sphere of radius vt and centre S.

xy be the primary wave front.

All points of primary wave front are the source of secondary wave front.

After t', secondary wave front travel a distance vt, travel to surface x_1y_1 and x_2y_2

where, x_1y_1 be the forward wave front.

x_2y_2 be the backward wave front.

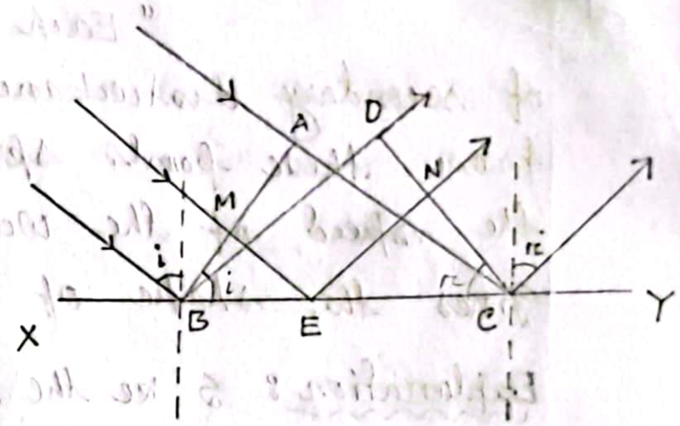
Limitations

According to the Huygen's the presence of backward wavefront is avoided because the amplitude of second wavefront is not unifrom in all direction. It is maximum in forward direction and zero in backward direction.

04+06

Q ## Reflection of a plane wavefront at a plane surface (Li

⇒ Let, XY be the plane surface. The incident wave front AMB. The angle of incidence is i and the angle of reflection is r.



All particles on AB will be vibrating in phase. In the interval of time the disturbance at A goes to C. Secondary wave front from B travel a distance BD equal to AC.

The angle of reflection is r.

From ΔABC and ΔDBC.

Bc is the common side of two triangle.

$BD = AC$

$\angle BAC = \angle BDC = 90°$

$\angle ABC = i = \angle BCD = \angle r$

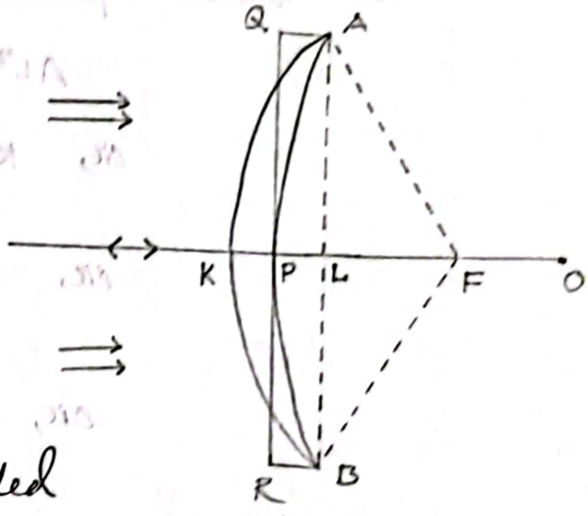
$\therefore \angle i = \angle r$

So the angle of incidence is equal to angle of reflection.

Reflection of a plane wavefront at a spherical surface.

OR, Prove that, $f = \frac{R}{2}$:

⇒ Let, APB be a convex reflecting surface and QPR the incident plane wavefront.



After a interval of time, the disturbance at Q and R reaches A and B.

The secondary wave front P travelled a distance PK back into the same medium.

$QA = RB = PL = PK$.

Here AKB form secondary spherical wavefront where centre of curvature F.

वक्रता

APB is small arc of circle of radius $PO = R$ and ALB is a chord.

$$AL^2 = PL(2R - PL)$$

$$\text{or, } AL^2 = 2R \cdot PL - PL^2$$

For small apertures, PL^2 is negligible.

$$AL^2 = 2R \cdot PL$$

$$\text{or, } R = \frac{AL^2}{2PL}$$

Similarly, For the spherical surface AKB.

$$AL^2 = KL(2R - KL)$$

$$\text{or, } AL^2 = KL(2 \cdot KF - KL)$$

or, $AL^2 = 2KF \cdot KL - KL^2$

For small apertures, KL^2 is negligible.

$$AL^2 = 2 \cdot KF \cdot KL$$

$$\text{or, } KF = \frac{AL^2}{2KL}$$

$$\text{or, } KF = \frac{AL^2}{2(KP + PL)}$$

$$\text{or, } KF = \frac{AL^2}{2(PL + PL)} \quad [\because KP = PL]$$

$$\text{or, } KF = \frac{AL^2}{2 \cdot 2PL}$$

$$\text{or, } f = \frac{R}{2} \text{ (approximately)}$$

So the reflection of plane wavefront at a spherical shape is $f = \frac{R}{2}$. Proved.

$$\therefore LM = \frac{AM^2}{2LO}$$
$$= \frac{AM^2}{2PO} = \frac{AM^2}{2u} \quad \text{---} ①$$

For spherical surface EPD,

$$PN = \frac{EN^2}{2PI}$$
$$= \frac{EN^2}{2v} = \frac{AM^2}{2v} \quad \text{---} ②$$
$$[\because AM = EN]$$

For spherical surface XPY,

$$PM = \frac{AM^2}{2PC}$$
$$= \frac{AM^2}{2R} \quad \text{---} ③$$

Also, $PL = AE = MN$

$$\therefore PN = PM + MN \quad [\because MN = PL]$$
$$= \boxed{PM + PL} \text{ Mind it}$$
$$= PM + PM - LM$$
$$= 2PM - LM$$

or, $PN + LM = 2PM$

or, $\frac{AM^2}{2v} + \frac{AM^2}{2u} = 2 \cdot \frac{AM^2}{2R}$ [From eqn ①, ② & ③]

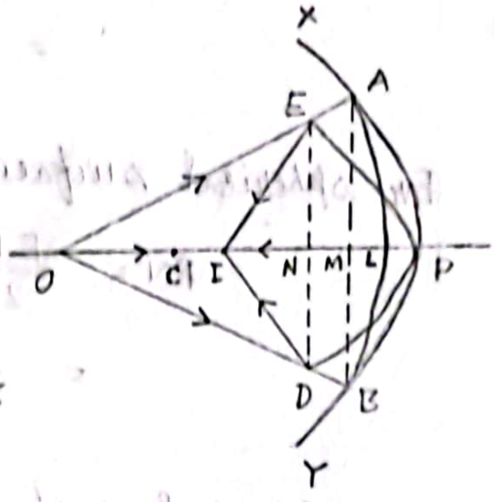
or, $\frac{AM^2}{2}\left(\frac{1}{v} + \frac{1}{u}\right) = \frac{AM^2}{2}\left(\frac{2}{R}\right)$

or, $\frac{1}{v} + \frac{1}{u} = \frac{2}{R}$

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

Proved.

Reflection of a spherical wavefront at a spherical surf.
OR, Prove that, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$



⇒ Let, XPY be a concave reflecting surface of radius R and centre of curvature C. O is a point source of light on the axis of the mirror. ALB be the incident spherical wavefront.

After interval of time, the disturbance at L reaches to P.

A and B must have travelled a disturbance.

$$AE = BD = PL$$

Therefore, EPD is the reflected spherical wavefront whose centre of curvature is I. I is the image of the object O.

Take, $PO = u$
$PI = v$
$PC = R$

For the spherical surface, ALB,

$$AM^2 = LM(2R - LM)$$

or, $AM^2 = 2R \cdot LM - LM^2$

or, $AM^2 = 2R \cdot LM$ $\quad$ [LM^2 negligible]

or, $AM^2 = 2LO \cdot LM$

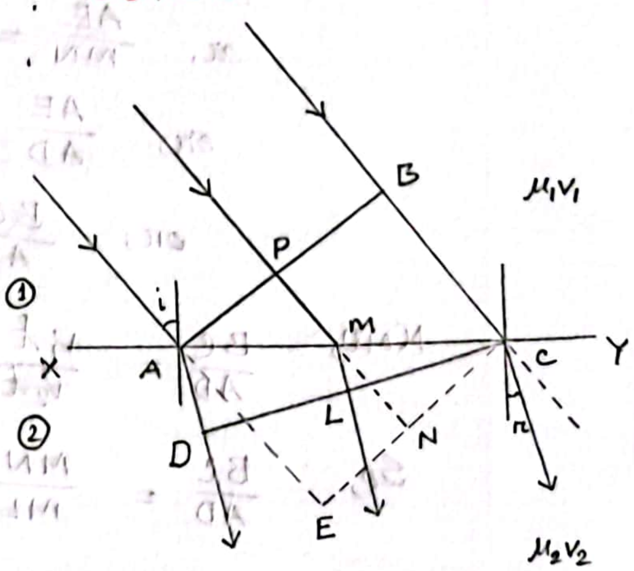
or, $LM = \frac{AM^2}{2LO}$.

H

(h) Refraction of a plane wavefront at a plane surface.

OR, Prove that, $\mu_1 \sin i = \mu_2 \sin r$. 06+08

OR, Prove that, $\sin c = \frac{1}{{}_2\mu_1}$.



⇒ Let, XY represent the surface separating the media 1 and 2 of refractive indices μ_1 and μ_2 respectively. V_1 and V_2 are the velocities of light in the two media. APB be the incident plane wavefront.

By the time the disturbance at B reaches to C.

The secondary wavefront from A travelled a distance $AD = V_2 t$ equal to $BC = V_1 t$.

Centre C and radius AD draw a sphere, tangent CD to the sphere from point C.

Then CLD refracted ~~from point C~~ plane wavefront.

From, ΔACD and ΔMCL.

$$\frac{AD}{ML} = \frac{AC}{MC} \quad \text{----} ①$$

From ΔACE and ΔMCN,

$$\frac{AE}{MN} = \frac{AC}{MC} \quad \text{----} ②$$

From eqn ① & ②, we get,

$$\frac{AD}{ML} = \frac{AE}{MN}$$

or, $$\frac{AE}{MN} = \frac{AD}{ML}$$

or, $$\frac{AE}{AD} = \frac{MN}{ML}$$

or, $$\frac{BC}{AD} = \frac{MN}{ML} \quad \cdots (3) \quad [\because AE = BC]$$

Now, $$\frac{BC}{AD} = \frac{v_1 t}{v_2 t} = \frac{v_1}{v_2} \quad \cdots (4)$$

So, $$\frac{BC}{AD} = \frac{MN}{ML} = \frac{v_1}{v_2} \quad \cdots (5)$$

Let, i and r be the angles of incidence and refraction respectively.

From ΔABC, $\sin i = \frac{BC}{AC}$

From ΔACD, $\sin r = \frac{AD}{AC}$

$$\therefore \frac{\sin i}{\sin r} = \frac{BC}{AC} \Big/ \frac{AD}{AC}$$

or, $$\frac{\sin i}{\sin r} = \frac{BC}{AC} \times \frac{AC}{AD} = \frac{BC}{AD} \quad \cdots (6)$$

Comparing eq^n (5) & (6).

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} \quad \left[\because \mu = \frac{c}{v}\right]$$

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

or, $$\mu_1 \sin i = \mu_2 \sin r$$

This is the snell's law of refraction.

Total internal reflection :

If the velocity of light v_2 in the second medium is greater than the velocity of light v_1 in the first medium and $AD > AC$.
Then no tangent can be drawn from c to the sphere drawn with A as centre.

In case, $AD = AC$

$$\sin i = \frac{BC}{AC}$$

or, $BC = AC \sin i$

or, $v_1 t = v_2 t \sin i$

or $v_1 = v_2 \sin i$

or, $\sin i = \frac{v_1}{v_2}$

or, $\sin i = {}_1\mu_2$

or, $\sin i = \frac{1}{{}_2\mu_1}$

where ${}_2\mu_1$ is the refractive index of the first medium with respect to the second medium.

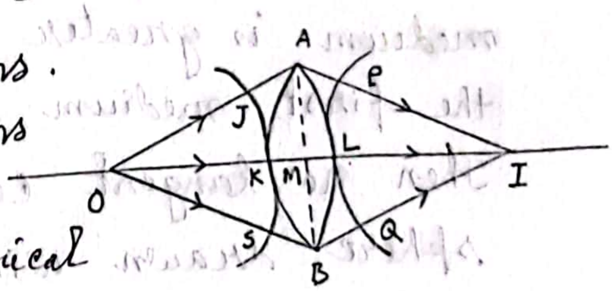
Here, $i = c$.

$$\therefore \sin c = \frac{1}{{}_2\mu_1}$$

Proved.

Prove that, $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ using Huygen's principle.

⇒ let, μ be the refractive index of the material of the lens. O is an object point on the lens axis and I is the image.



let, JKS be the incident spherical wavefront. By the time the disturbance at the points J and S reaches the points P and Q the secondary waves from the point K must have travelled a distance KL through the medium of the lens. Therefore, PLQ forms the refracted spherical wavefront whose centre of curvature is I. Hence I is the image of O.

Also, the optical path,

$$OA + AI = OK + \mu KL + LI$$

$$\text{or, } OA + AI = (OM - KM) + \mu(KM + ML) + (MI - ML) \quad \text{---} (1)$$

let, R_1 = Radious of the curvature of AKB

R_2 = Radious of the curvature of ALB

u = Object distance of MO.

v = Image distance of MI.

and, $AM = h$.

In the, ΔOAM, $OA^2 = OM^2 + AM^2$

$$= OM^2\left[1 + \frac{AM^2}{OM^2}\right]$$

$$\text{or, } OA = OM\left[1+\frac{AM^2}{OM^2}\right]^{\frac{1}{2}}$$

$$= u\left[1+\frac{h^2}{u^2}\right]^{1/2}$$

$$= u\left[1+\frac{h^2}{2u^2}+----\right] \text{ [Applying Binomial theorem]}$$

$$= u+\frac{h^2}{2u} \quad ----- \quad ②$$

Similarly, From the ΔAMI,

$$AI^2 = MI^2 + AM^2$$

$$= MI^2\left[1+\frac{AM^2}{MI^2}\right]$$

$$\text{or, } AI = MI\left[1+\frac{AM^2}{MI^2}\right]^{1/2}$$

$$= v\left[1+\frac{h^2}{v^2}\right]^{1/2}$$

$$= v\left[1+\frac{h^2}{2v^2}+-----\right]$$

$$= v+\frac{h^2}{2v} \quad ---- \quad ③$$

For the spherical surface AKB,

$$KM = \frac{h^2}{2R_1}$$

and for the spherical surface ALB.

$$LM = \frac{h^2}{2R_2}$$

$$\therefore KM + LM = KL$$

From equation ①,

$$\left(u+\frac{h^2}{2u}\right)+\left(v+\frac{h^2}{2v}\right)=\left\{\left(u-\frac{h^2}{2R_1}\right)+\mu\left(\frac{h^2}{2R_1}+\frac{h^2}{2R_2}\right)+(v\right.$$

or, $$\frac{h^2}{2u}+\frac{h^2}{2v}=\mu\left(\frac{h^2}{2R_1}+\frac{h^2}{2R_2}\right)-\left(\frac{h^2}{2R_1}+\frac{h^2}{2R_2}\right)$$

or, $$\frac{1}{u}+\frac{1}{v}=\mu\left(\frac{1}{R_1}+\frac{1}{R_2}\right)-\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$$

or, $$\frac{1}{u}+\frac{1}{v}=(\mu-1)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$$

Again, we know, $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$.

$$\therefore \quad \frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$$

Proved.

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[signature]

06.12.09

SPECTROMETER :

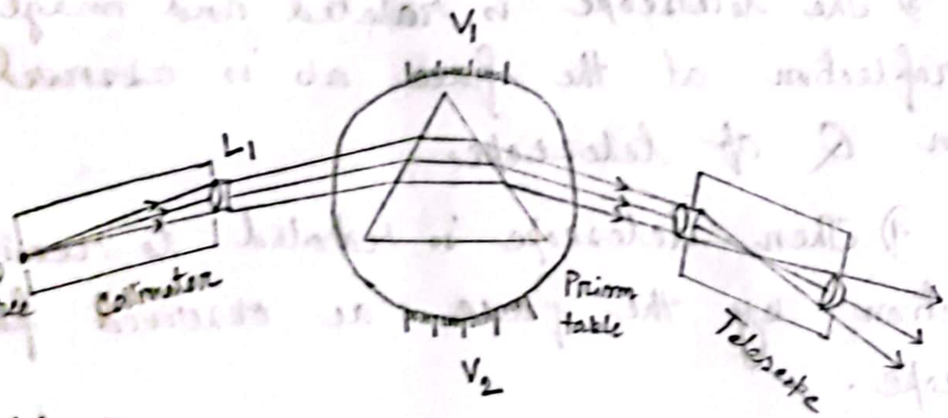
It spectrometer consists mainly of three parts,

1) Collimator.
2) Prism table.
3) Telescope.

1) **Collimator :** i) It consists of achromatic lens L_1 on which source of light from S falls.

ii) The slit of collimator is placed in front of source of light at a focal distance and width of slit is adjusted by the screw.

iii) Ray coming through lens L_1 is parallel and incident on prism/grating.



2) **Prism table :** i) Table is adjust with proper position by sprit level.

ii) Prism/grating set on table and by the telescope observation of image then reading can be recorded from scale V_1 and V_2.

3) Telescope : i) It is fitted with a Ramsden's eyepiece and cross wire set on parallel beam coming from prism/ grating.

ii) When parallel beam from prism/grating falls on the object, the spectrum produce is viewed through eyepice and observed the final image by eyepices.

Angle of the prism :-

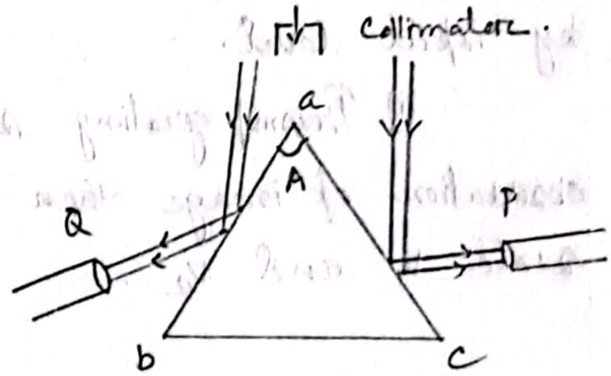
1) After setting spectrometer the prism is placed on the table. Slit is adjusted to source of light.

2) Both face of prism ie refracting edges ab and ac receive light from collimator.

3) The telescope is rotated and image formed by the reflection at the face ab is observed through position Q of telescope.

4) Then telescope is rotated to receive light reflection by the face ac observed position P of telescope.

5) The angle betn position P and Q is twices the angle of prism.

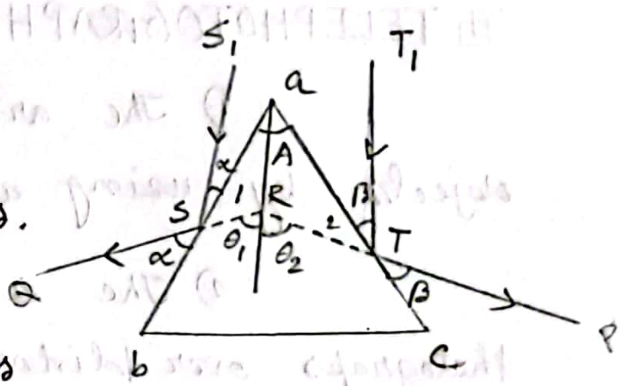


Angle of prism :

In figure, $\angle cab = \angle A =$ Prism angle

S_1S and T_1T is the incident rays on prism.

SQ and TP be the reflected rays by prism.



$\angle 1 = \angle QSb = \angle \alpha$

$\angle 2 = \angle CTP = \angle \beta$.

In ΔSRa, $\theta_1 = \angle 1 + \angle \alpha$

$= \angle \alpha + \angle \alpha$.

or, $\theta_1 = 2\angle \alpha$ ——— (1)

In ΔTRa, $\theta_2 = \angle 2 + \angle \beta$.

$= \angle \beta + \angle \beta$.

or, $\theta_2 = 2\angle \beta$ ——— (2)

$\therefore \theta_1 + \theta_2 = 2\angle \alpha + 2\angle \beta$

$= 2(\angle \alpha + \angle \beta)$.

$= 2\angle A$.

$\therefore \theta = 2A$ $\quad [\because \theta = \theta_1 + \theta_2]$.

Therefore the angle between the reflected rays SQ and TP is equal to twice the angle of the prism.

TELEPHOTOGRAPHY :

1) The art or process of photography distant objects by using a telephone lens.

2) The science or Process of transmitting photograps over distance by converting light rays into electric signals, which are sent over wire or radio chanels. The receiver converts the electric signals into light rays to which a photograpic film is exposed.

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07.12.09

Again we know, $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$

$$\therefore \frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$$ (proved)

☐ Mention some applications of measuring the velocity of light in free space in physics.

Ans: The value of velocity of light in vacuum is of great importance in physics and the velocity of light is represented by c. It is a universal constant.

$$C = 299792.5 \pm 0.4 \text{ km/sec}$$

It is useful in some important calculations.

(1) from the relation $c=\nu\lambda$, the frequency of electromagnetic radiations can be calculated, if the wavelength is known. This relation has been found useful in determining the frequency or wavelength of spectral lines & of wireless waves.

(2) Einstein formulated his theory of relativity depending upon c. According to his theory,

$$m=\frac{m_0}{\sqrt{1-v^2/c^2}}$$

where, m_0 represents the rest mass & m be the mass, when it is moving with a velocity v.

According to his relation if $v=c$

then, $m=\infty$

Wild dreams

③ The constant value of c has given a relation betⁿ mass & energy $E = mc^2$, which represents conversion of mass into energy & energy into mass. This has been found useful in calculating the amount of energy produced during atomic fission & atomic fussion.

④ $E = mc^2$

$E = h\nu$

where h is planck's constant & ν is the frequency of radiation.

$\therefore h\nu = mc^2$

or, $m = \frac{h\nu}{c^2}$

Therefore, an energy E conveyed by a given quantity of radiation can be regarded due to a mass $\frac{h\nu}{c^2}$ moving with a velocity c.

Therefore, momentum, $\frac{h\nu}{c^2} \cdot c = \frac{h\nu}{c}$

⑤ It is useful in the conversion of e.m.u to esu & vice versa

(I) 1 emu charge = c esu of charge.

(II) 1 emu of potential $= \frac{1}{c}$ esu of potential.

(III) 1 emu of capacity $= c^2$ esu of capacity.

MATHMATICAL PROBLEM

Q. An incident ray of W.L 4500A° in air & plane surface of Quartz & make angle 30° with normal. If the refractive index of quartz w.r.to air is 1.466. find the angle of refraction
—C.L

Solution:

We know,

$\mu_1 \sin i = \mu_2 \sin r$

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

or, $\sin r = \frac{1.466}{1.003} \sin 30°$

or, $r = \sin^{-1}(0.712)$

$\therefore r = 45.37°$ Ans

Here.

The angle of incidence, $i = 30°$

Refractive index of air, $\mu_2 = 1.003$

" " " Quartz, $\mu_1 = 1.466$

The angle of refraction, $r = ?$

P. The speed of sodium light in a certain liquid is $1.92 \times 10^8 ms^{-1}$! What is the refractive index of the liquid? —C.L

Solution:

We know,

$\mu = \frac{c}{v}$

$= \frac{3 \times 10^8}{1.92 \times 10^8}$

$= 1.56$ Ans

Here,

$c = 3 \times 10^8 ms^{-1}$

$v = 1.92 \times 10^8 ms^{-1}$

$\mu = ?$

Q The wavelength of Red light in air is 7000A°. What is its wavelength in glass? [refractive index of glass is 1.5]

Solution:

We know,

$$\mu = \frac{\lambda}{\lambda_m}$$

$$\text{or, } \lambda_m = \frac{\lambda}{\mu}$$

$$= \frac{7000 \times 10^{-10}}{1.5}$$

$$= 4.67 \times 10^{-7} m \quad \underline{\underline{Ans}}$$

Here,

$\lambda = 7000 A°$

$= 7000 \times 10^{-10} m$

$\mu = 1.5$

$\lambda_m = ?$

17/11/13   22/9/19

Continuous Assessment