EDUCATIONAL GROUP
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Refraction of light through Prism

XII- SCIENCE

SUBJECT : PHYSICS
CHAPTER NUMBER: 9
CHAPTER NAME : RAY OPTICS

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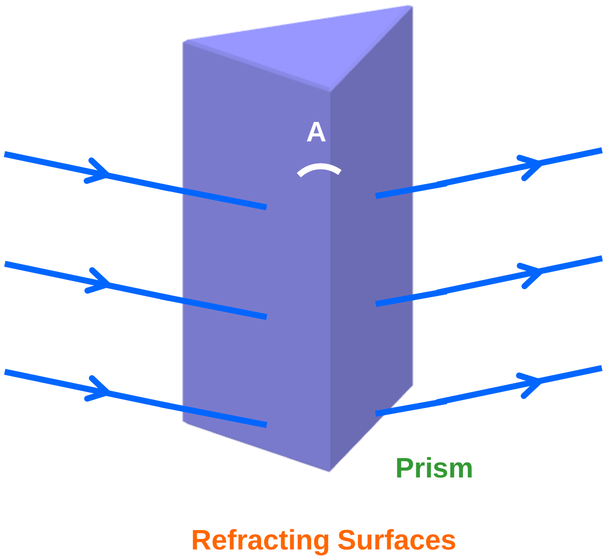
Refraction of Light through Prism:



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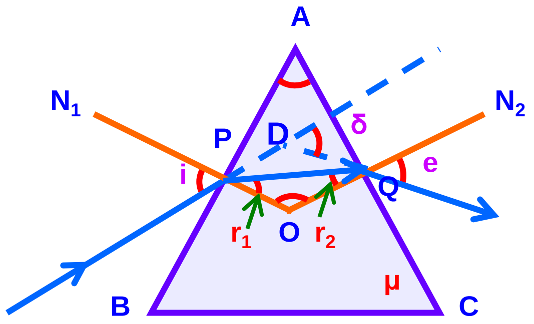

In quadrilateral APOQ,

$A + O = 180°$ …….(1)

(since N_1 and N_2 are normal)

In triangle OPQ,

$r_1 + r_2 + O = 180°$ …….(2)

In triangle DPQ,

$\delta = (i - r_1) + (e - r_2)$

$\delta = (i + e) - (r_1 + r_2)$ …….(3)

From (1) and (2),

$A = r_1 + r_2$

From (3),

$\delta = (i + e) - (A)$

or $i + e = A + \delta$

Sum of angle of incidence and angle of emergence is equal to the sum of angle of prism and angle of deviation.

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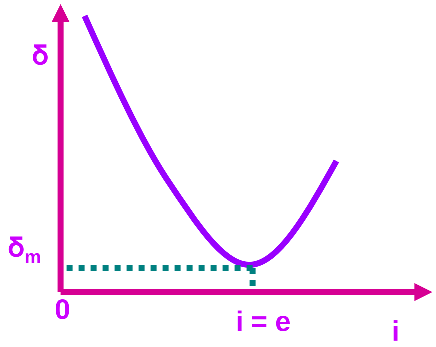
Variation of angle of deviation with angle of incidence:

When angle of incidence increases, the angle of deviation decreases.

At a particular value of angle of incidence the angle of deviation becomes minimum and is called **'angle of minimum deviation'**.

At δ_m, $i = e$ and $r_1 = r_2 = r$ (say)

After minimum deviation, angle of deviation increases with angle of incidence.



Refractive Index of Material of Prism:

$A = r_1 + r_2$

$A = 2r$

$r = A / 2$

$i + e = A + \delta$

$2i = A + \delta_m$

$i = (A + \delta_m) / 2$

According to Snell's law,

$$\mu = \frac{\sin i}{\sin r_1} = \frac{\sin i}{\sin r}$$

$$\therefore \quad \mu = \frac{\sin \frac{(A + \delta_m)}{2}}{\sin \frac{A}{2}}$$

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Refraction by a Small-angled Prism for Small angle of Incidence:

$$\mu = \frac{\sin i}{\sin r_1} \quad \text{and} \quad \mu = \frac{\sin e}{\sin r_2}$$

If i is assumed to be small, then r_1, r_2 and e will also be very small. So, replacing sines of the angles by angles themselves, we get

$$\mu = \frac{i}{r_1} \quad \text{and} \quad \mu = \frac{e}{r_2}$$

$i + e = \mu (r_1 + r_2) = \mu A$

But $i + e = A + \delta$

So, $A + \delta = \mu A$

or $\boxed{\delta = A (\mu - 1)}$

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Numerical : At what angle should a ray of light be incident on the face of a prism of refracting angle 75^0 and refractive index $\sqrt{2}$ so that it just suffers total internal reflection at the other face ?

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Solution : At second face ray suffers just internal reflection means $r_2 = i_C$.

As $i_C = \sin^{-1}\frac{1}{\mu} = \sin^{-1}\frac{1}{\sqrt{2}} = 45^0 \Rightarrow r_2 = 45^0$

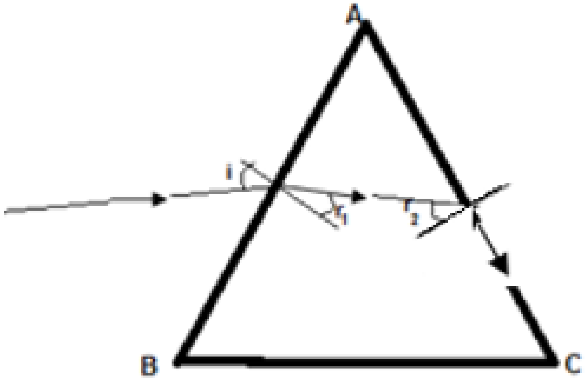
Since $A = r_1 + r_2 \Rightarrow r_1 = A - r_2 = 75^0 - 45^0 = 30^0$

Again by Snell's law at face AB ;

$$\frac{\sin i}{\sin r_1} = \mu \Rightarrow \sin i = \mu \sin r_1 = \sqrt{2}\sin 30^0$$

$$\Rightarrow \sin i = \sqrt{2} \times \frac{1}{2} = \frac{1}{\sqrt{2}}$$

$$\Rightarrow i = \sin^{-1}\frac{1}{\sqrt{2}} = 45^0$$



Numerical : A ray grazing along 1st face of a prism of refracting angle A enters into prism and also grazes along the other face also ? Obtain an expression for its refractive index .

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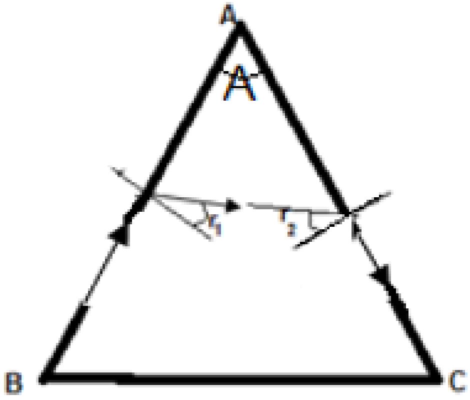
Solution : In this case i = e = 90^0 . $\Rightarrow r_1 = r_2$

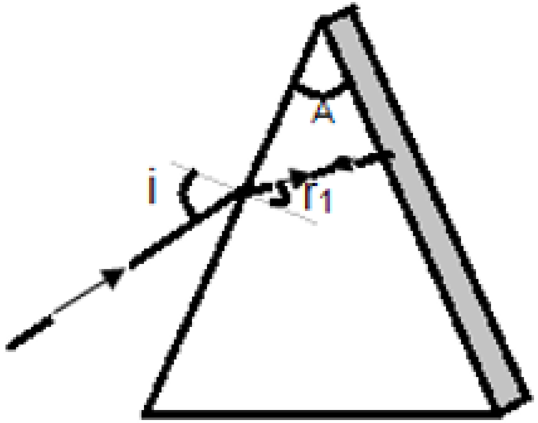
As $A = r_1 + r_2 \Rightarrow A = 2r_1 \Rightarrow r_1 = \frac{A}{2}$

Again by Snell's law in 1st face , $\sin i = \mu \sin r_1$

$$\Rightarrow \sin 90^0 = \mu \sin(A/2) \Rightarrow \mu = \frac{1}{\sin(A/2)} = \mathrm{cosec}(A/2)$$



Numerical : One face of a prism with refracting angle 30^0 is coated with silver . A ray incident on the other face at an angle of 45^0 is refracted and reflected from the silver coated face and retraces its path . Find the refractive index of the material of the prism .



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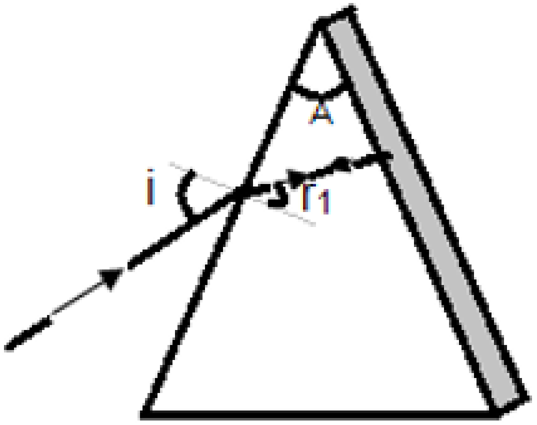


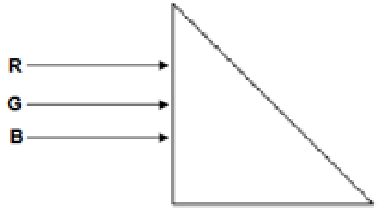
Solution : As the ray retraces its path , hence it is striking the silvered surace perpendicularly .

$$\Rightarrow r_2 = 0^0$$

As $A = r_1 + r_2 \Rightarrow r_1 = A - r_2 = A = 30^0$

Using Snell's law for refraction t 1st face we have; $\mu = \dfrac{\sin i}{\sin r_1} = \dfrac{\sin 45^0}{\sin 30^0} = \dfrac{1/\sqrt{2}}{1/2} = \sqrt{2}$

Numerical : A beam of light consisting rays of red (R) , green (G) and blue (B) enter perpendicularly at one face of a right angled isosceles triangle in to its material . The material has refractive indices 1.39 , 1.44 and 1.47 for red , green and blue colours respectively . Trace their paths by showing proper reason . What would happen if the prism were an equillateral prism in place of right angled isosceles prism ?



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