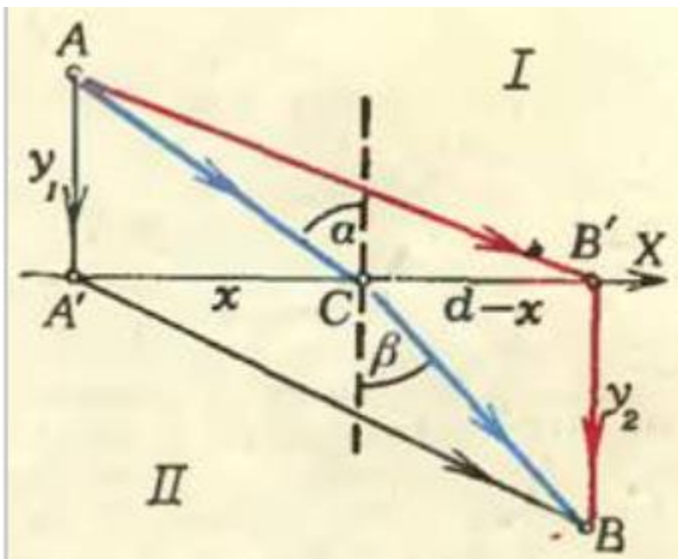
Answer on Question #74719, Physics / Optics

State Fermat's principle. On the basis of this principle, show that when light passes from a medium of lower refractive index to a medium of higher refractive index, it bends towards the normal to the interface between the two media.

Answer:

Fermat's principle states that the optical length of the path followed by light between two fixed points, A and B, is an extremum (minimal or maximal)

For a border of two mediums:



$AB = \sqrt{y_1^2 + x^2}\ , CB = \sqrt{y_2^2 + (x-d)^2}$

$t_1 = \frac{\sqrt{y_1^2+x^2}}{v} = \frac{n_1\sqrt{y_1^2+x^2}}{c}$

$t_2 = \frac{n_2\sqrt{y_2^2+(x-d)^2}}{c}$

$t = t_1 + t_2 = \frac{n_1\sqrt{y_1^2+x^2}}{c} + \frac{n_2\sqrt{y_2^2+(x-d)^2}}{c}$

Extremal (Fermat's principle): $\frac{dt}{dx} = 0 \rightarrow \frac{2n_1 x}{c\sqrt{y_1^2+x^2}} = \frac{-2n_2(x-d)}{c\sqrt{y_2^2+(x-d)^2}} \rightarrow \frac{n_1 x}{\sqrt{y_1^2+x^2}} = \frac{n_2(d-x)}{\sqrt{y_2^2+(x-d)^2}}$

$As\!: \ sin\alpha = \frac{x}{\sqrt{y_1^2+x^2}}, sin\beta = \frac{d-x}{\sqrt{y_1^2+x^2}} \rightarrow n_1 sin\alpha = n_2 sin\beta$

$As\ n_2 > n_1 \rightarrow\ \alpha > \beta - light\ bends\ toward\ the\ normal$

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