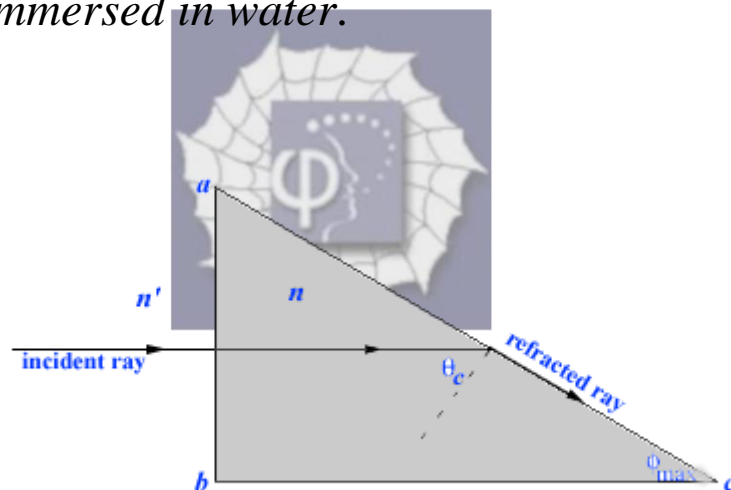


604.

Problem 43.42 (RHK)

A ray of light is incident normally on the face ab of a glass prism ($n=1.52$), as shown in the figure. (a) Assuming that the prism is immersed in air, we have to find the largest value for the angle ϕ so that the ray is totally reflected at the face; (f) we have to find ϕ if the prism is immersed in water.



Solution:

Let n be the index of refraction of the glass prism and n' be that of the outside medium in which the prism is kept. For total internal reflection to take place, it is necessary that

$$n' < n.$$

The critical angle for total reflection θ_c is determined by the condition

$$n \sin \theta_c = n'.$$

And this angle fixes the largest value of the prism angle ϕ_{\max} for the incident light to get refracted along the edge of the prism, as shown in the figure. We have

$$\phi_{\max} = \frac{\pi}{2} - \theta_c = \frac{\pi}{2} - \sin^{-1} \left(\frac{n'}{n} \right).$$

(a)

When the prism is kept in air, we have

$$n = 1.52, \text{ and } n' = 1.$$

$$\therefore \phi_{\max} = \frac{\pi}{2} - \sin^{-1} \left(\frac{1}{1.52} \right) = (90^\circ - 41.1^\circ) = 48.9^\circ.$$

(b)

When the prism is immersed in water $n' = 1.33$.

$$\therefore \phi_{\max} = \frac{\pi}{2} - \sin^{-1} \left(\frac{1.33}{1.52} \right) = (90^\circ - 61^\circ) = 29^\circ.$$