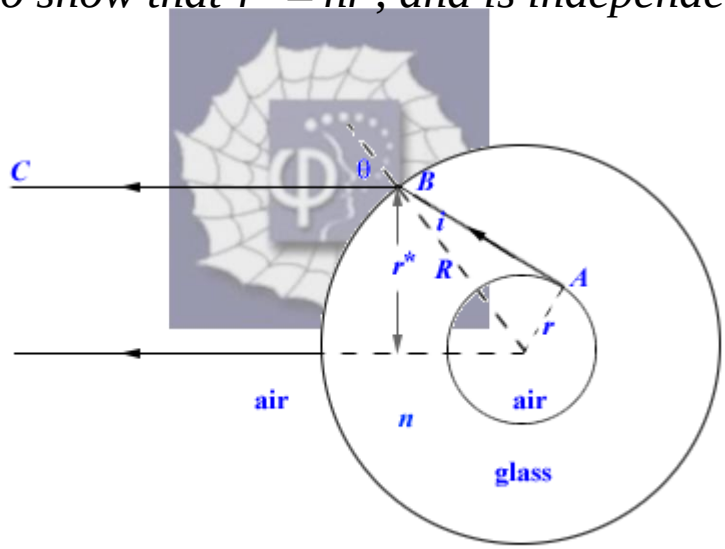
609.

Problem 44.7 (RHK)

In the figure cross section has been shown of a hollow glass tube of internal radius r, external radius R, and index of refraction n. (a) *We have to convince ourselves that the ray ABC shown in the figure defines the apparent internal radius* r^* *as seen from the side.* (b) *We have to show that* $r^* = nr$ *, and is independent of R.*



Solution:

To an observer facing the hollow glass tube the size of the inner part of the glass tube will be determined by the parallel rays as shown in the figure. The apparent internal

radius r^* will be the perpendicular distance between the ray BC and a parallel ray passing through the axis.

We use the Snell's law of refraction and the geometry of the line drawing for calculating r^*.

Let i be the angle of incidence that the ray AB tangential to the inner surface of the tube make with the external surface of the tube. Let θ be the angle of refraction.

We have

$$n\sin i = \sin\theta.$$

From the figure we note that

$$\sin i = \frac{r}{R},$$

and

$$\sin\theta = \frac{r^*}{R}.$$

Substituting these results in the refraction equation, we get

$$r^* = nr,$$

which is independent of R.