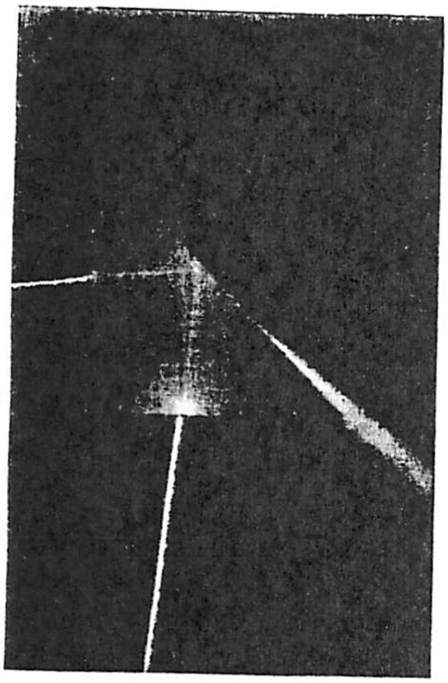
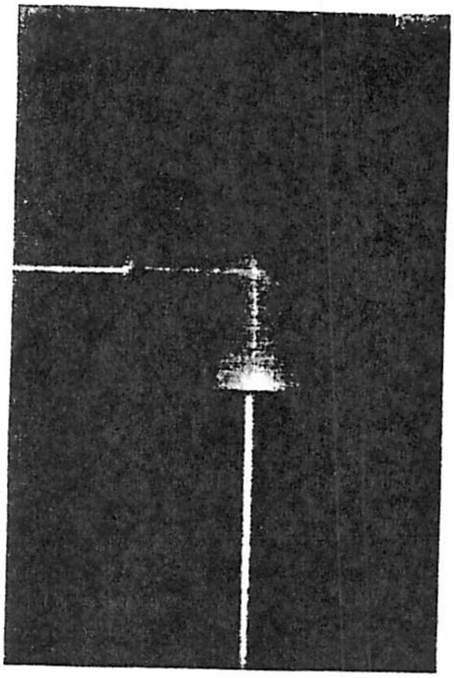
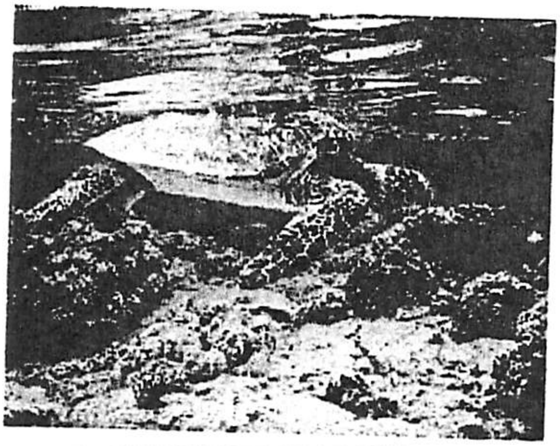


(a)



(b)

Figure 3.12. (a) The beam incident from the left has an internal incident angle that is slightly less that the critical angle. The transmitted beam just grazes the interface. (b) Total internal reflection. (GIPhotoStock/Photo Researchers, Inc.)



Wikipedia

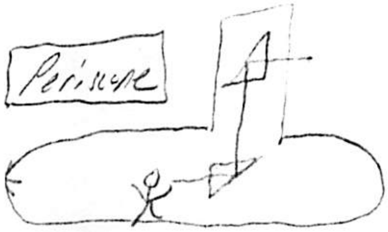
$n_{water} = 1.33$ $\sin\theta_c = \frac{1}{1.33}$ $\theta_c = 49^0$

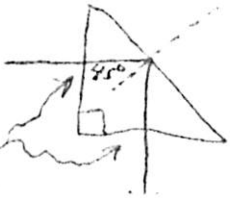
$n_g \approx 1.50$

$\theta_c = 42^\circ < 45^0$

Making 90° turns are especially useful (and retroreflections) : right angle prism

Periscope





small reflection

$r = \frac{n_i - n_t}{n_i + n_t} = -0.2$

Rule of thumb

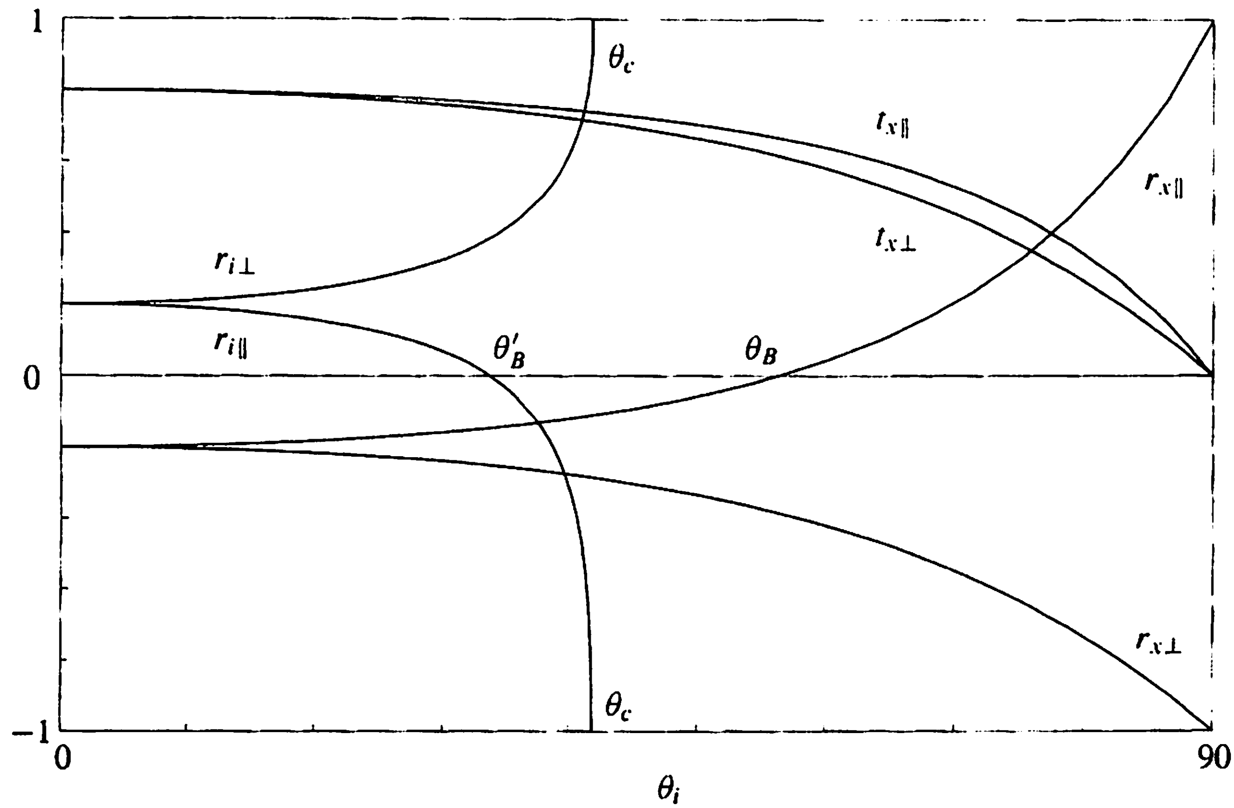


Figure 3.13. Fresnel amplitude ratios for internal and external incidence for an air-glass ($n = 1.50$) interface. Ratios subscripted with x are for external incidence, and ratios subscripts with i are for internal incidence. Transmission ratios for internal incidence are not shown.

At 0°, $t_{i\perp} = t_{i\parallel} = \frac{2n_i}{n_i+n_t} = 1.2$

In general, using Snell's law to eliminate θ_t:

$$t_\perp = \frac{2n_i\cos\theta_i}{n_i\cos\theta_i + n_t\sqrt{1-\left(\frac{n_i}{n_t}\sin\theta_i\right)^2}} \qquad t_\parallel = \frac{2n_i\cos\theta_i}{n_i\sqrt{1-\left(\frac{n_i}{n_t}\sin\theta_i\right)^2} + n_t\cos\theta_i}$$

For internal incidence, we have TIR @ $\sin\theta_c = \frac{n_t}{n_i}$

$$t_{i\perp} = 2 \qquad t_{i\parallel} = 2\frac{n_i}{n_t} = 3$$

Phase change summary:

• transmitted wave is not phase shifted

• reflected wave

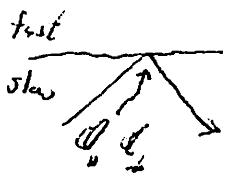
☆ external incidence ($n_i < n_t$): π phase shift

☆ internal incidence ($n_i > n_t$): 0 " for $\theta < \theta_c$

☆ " " : variable " for $\theta > \theta_c$

(notes p 28, text 3.5.3)

$\Delta\varphi \equiv \varphi_\parallel - \varphi_\perp$



$\sin\theta_c = \frac{n_t}{n_i} = 1.50$ $\theta_c = 42^\circ$

$= 2.42$ $\theta_c = 24^\circ$

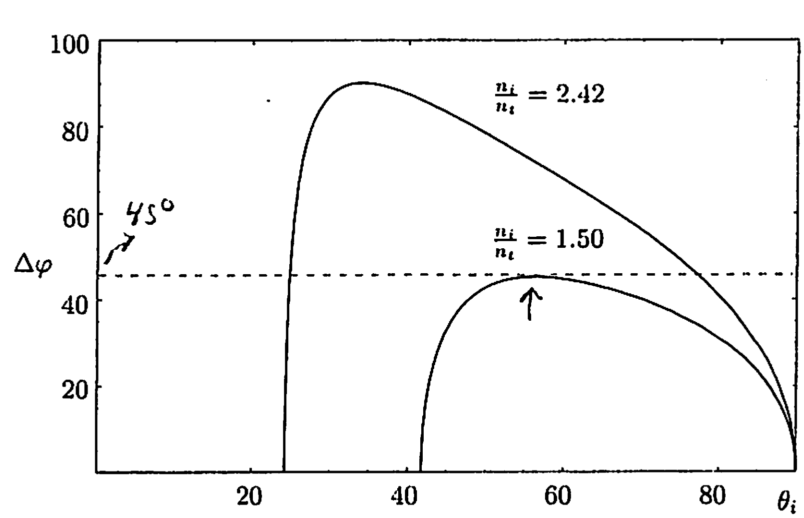
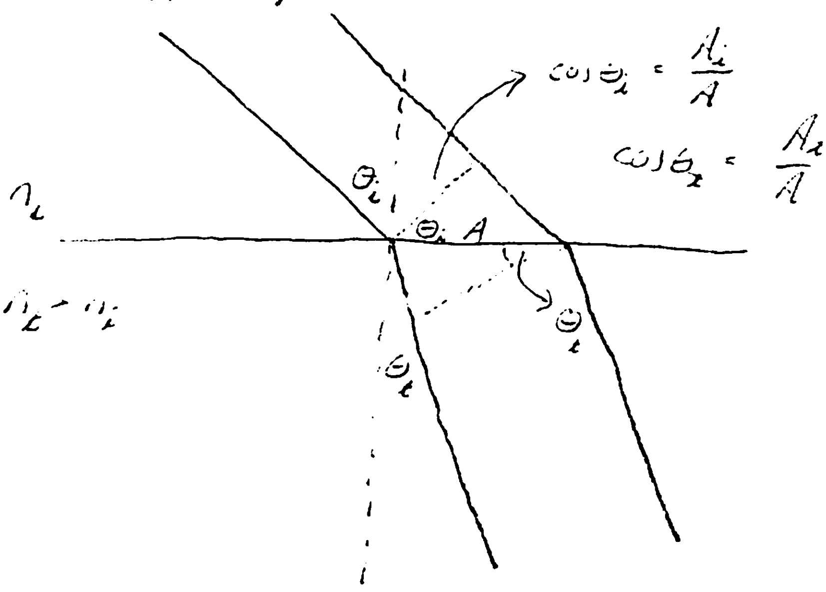
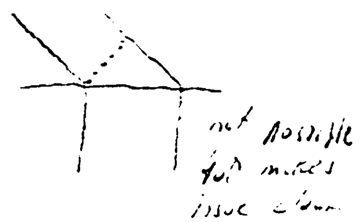


Figure 3.16 Relative phase shift $\Delta\varphi = \varphi_\parallel - \varphi_\perp$ for total internal reflection.

Reflectivity and Transmissivity

How much power is reflected or transmitted? $\vec{E}_i \to \vec{E}_r, \vec{E}_t \to I \to P$
need area





$$I = \frac{\epsilon v}{2} E_0^2 \qquad v = \frac{c}{n} \qquad n = \sqrt{\frac{\varepsilon}{\varepsilon_0}} \to \varepsilon = \varepsilon_0 n^2$$

$$= \frac{\varepsilon_0 n c}{2} E_0^2$$

$$R = \frac{P_r}{P_i} = \frac{I_r A_i}{I_i A_i} = \frac{E_{0r}^2}{E_{0i}^2} = r^2 \checkmark \qquad (\text{really } |r|^2 = r r^*)$$

$$T = \frac{P_t}{P_i} = \frac{I_t A \cos\theta_t}{I_i A \cos\theta_i} = \frac{n_t E_{0t}^2}{n_i E_{0i}^2} \frac{\cos\theta_t}{\cos\theta_i} = \left(\frac{n_t \cos\theta_t}{n_i \cos\theta_i}\right) t^2 \checkmark$$

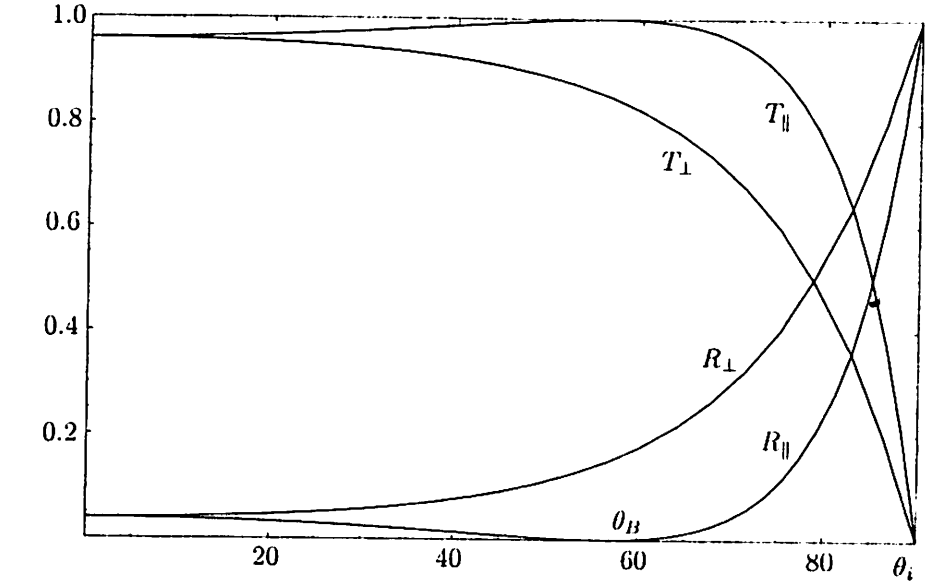
$$R_\perp = \left(\frac{n_i \cos\theta_i - n_t \cos\theta_t}{n_i \cos\theta_i + n_t \cos\theta_t}\right) \qquad R_\parallel = \frac{n_t \cos\theta_i - n_i \cos\theta_t}{n_i \cos\theta_t + n_t \cos\theta_i}$$

(see text eqs 3.57 and following)

$$T_\perp = \frac{4 n_i n_t \cos\theta_i \cos\theta_t}{(\quad)^2} \qquad T_\parallel = \frac{4 n_i n_t \cos\theta_i \cos\theta_t}{(\quad)^2}$$

$$R + T = 1$$

34



$\theta_B = 56°$

$\theta_B' = 34°$

$\theta_c = 42°$

Figure 3.18 Reflectivity and Transmissivity for external incidence when $n_i = 1.00$ and $n_t = 1.50$.

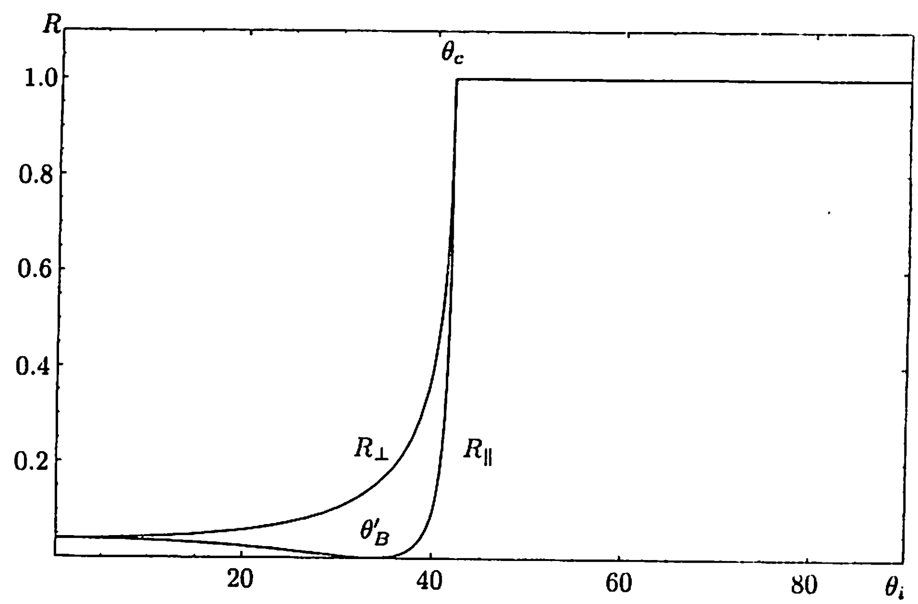
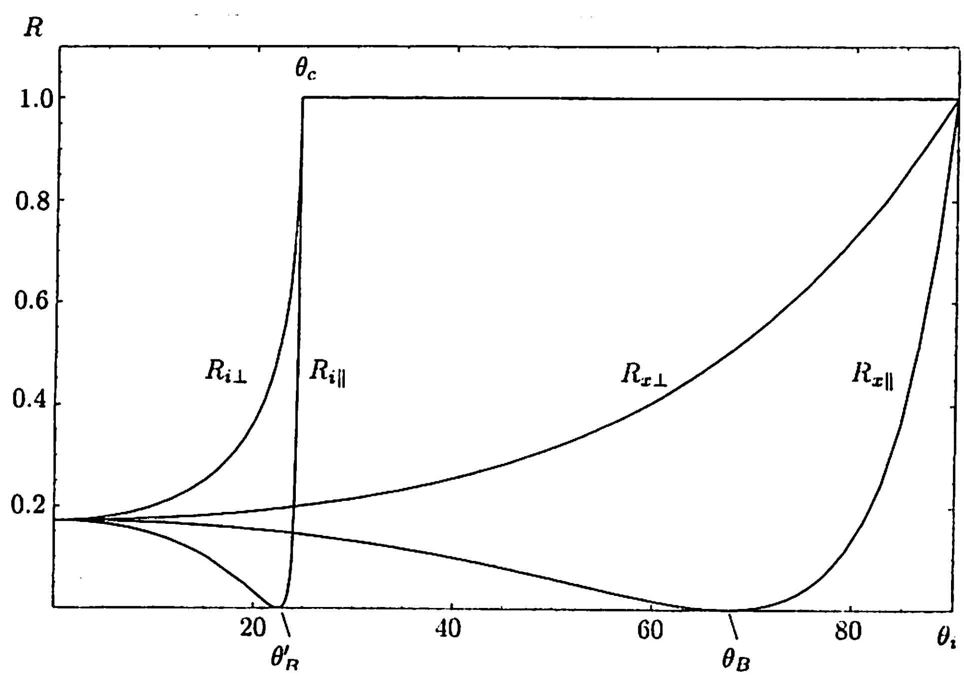


Figure 3.19 Reflectivity for internal incidence when $n_i = 1.00$ and $n_t = 1.50$.



$n_{diamond} = 2.42$

$\theta_B = 68°$

$\theta_B' = 22°$

$\theta_c = 24°$