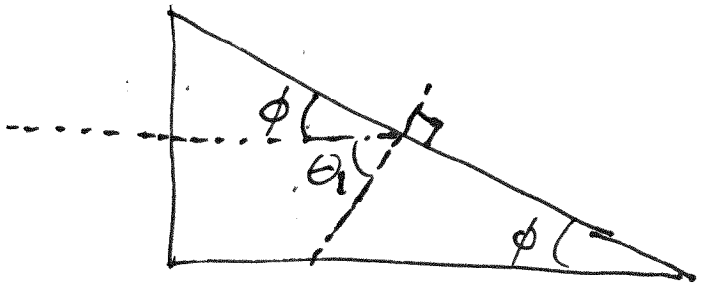
Ch. 1 Prob. 53



$n_{glass} = n_1 = 1.50$

$n_{air} = n_2 = 1.000$




a) Find the largest angle $\phi$ that results in total reflection on the slanted face.

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When light hits the slanted surface, it makes an angle of $\theta_1$ with respect to the surface normal.

By geometry $\phi$ is the complement of $\theta_1$.
(Notice from the illustration above, the incoming ray of light is parallel with the base of the prism. ∴ the angle $\phi$ extends from the surface of the prism to the light ray, the angle $\theta_1$ goes from the light ray to the ⊥ to the slanted surface.)

Now use Snell's law $n_1 \sin\theta_1 = n_2 \sin\theta_2$

solve for $\theta_1$ gives $\sin\theta_1 = \frac{n_2}{n_1}\sin\theta_2$

looking for critical angle

$\sin\theta_1 = \frac{n_{air}}{n_{glass}}\sin 90°$

$\sin\theta_1 = \frac{1.000}{1.333} = 0.7502$

$\theta_1 = 48.61°$

however $\phi$ is the complement of this angle

∴ $\phi = 90 - 48.61$

$\phi = 41.39°$

Ch.1 Prob.53



$$\sin\theta_c = \frac{n_{air}}{n_{glass}} \sin 90^\circ \leftarrow \text{looking for critical angle}$$

$$\sin\theta_c = \frac{1.000}{1.500} = 0.6667$$

$$\theta_c = 41.81^\circ$$

However, $\phi$ is the complement of this angle.

$$\therefore \phi = 90^\circ - 41.81^\circ = \boxed{48.19^\circ}$$

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b) Now Immerse the prism in water.

Since $n_2 = n_{H_2O} = 1.333$, Then

$$\sin\theta_c = \frac{n_{water}}{n_{glass}} \sin 90^\circ$$

$$\sin\theta_c = \frac{1.333}{1.500} = 0.8887$$

$$\theta_c = 62.71^\circ$$

$\phi$ is the complement of this angle.

$$\therefore \phi = 90^\circ - 62.71^\circ = \boxed{27.29^\circ}$$