

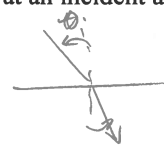
HW 8.3 Refraction and Critical Angle

Per _____ Name _____

$n_{\text{air}} = 1$ $n_{\text{water}} = 1.33$ $n_{\text{glass}} = 1.55$

1. The index of refraction of ordinary glass for red light is 1.51 and for violet light is 1.53. A beam of white light falls on a cube of such glass at an incident angle of 40 degrees. What is the difference between the angle of refraction of the red and violet light?

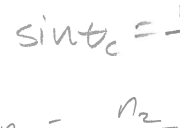
$n_{\text{red}} = 1.51$
 $n_{\text{violet}} = 1.53$
 $n_{\text{air}} = 1$
 $\theta_i = 40^\circ$



$n_1 \sin \theta_i = n_2 \sin \theta_r$
 $\theta_{\text{red}} = \sin^{-1} \left(\frac{\sin(40^\circ)}{1.51} \right) = 25.19^\circ$
 $\theta_{\text{violet}} = \sin^{-1} \left(\frac{\sin(40^\circ)}{1.53} \right) = 24.84^\circ$
 $\Delta = 0.35^\circ$

2. The critical angle for total internal reflection in lucite is 41 degrees. Find lucite's index of refraction.


$\theta_c = 41^\circ$
 $n_2 = 1$
 $n_1 = ?$



$\sin \theta_c = \frac{n_2}{n_1}$
 $n_1 = \frac{n_2}{\sin \theta_c} = \frac{1}{\sin(41^\circ)} = 1.52$

3. What is the angle of refraction of a beam of light that enters the surface of a lake at an angle of incidence of 50 degrees? ($n_{\text{water}} = 1.33$)

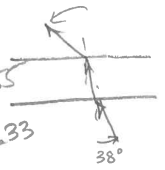
$n = 1$
 $n = 1.33$



$\sin 50 = 1.33 \sin \theta_r$
 $\theta_r = \sin^{-1} \left(\frac{\sin 50}{1.33} \right) = 35^\circ$

4. Light enters a piece of glass from water at a 38 degree angle. After passing through the glass, the light travels into air. Find the angle the light makes when traveling into the air.

$n = 1$
 $n = 1.55$
 $n = 1.33$



$n_1 \sin \theta_1 = n_2 \sin \theta_2 = n_3 \sin \theta_3$
 $1.33 \sin 38^\circ = 1 \sin \theta_3$
 $\theta_3 = \sin^{-1} (1.33 \sin 38^\circ) = 54.97^\circ$

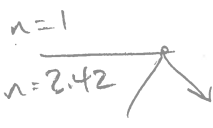
5. The speed of light in a certain type of glass is 1.91×10^8 m/s. What is the index of refraction of the glass?

$v = 1.91 \times 10^8 \text{ m/s}$
 $c = 3 \times 10^8 \text{ m/s}$
 $n = ?$

$n = \frac{c}{v} = \frac{3 \times 10^8}{1.91 \times 10^8} = 1.57$

6. What is the critical angle for light passing from a diamond ($n = 2.42$) to air?


$\theta_c = ?$
 $n = 1$
 $n = 2.42$



$2.42 \sin \theta_c = 1 \sin(90)$
 $\theta_c = \sin^{-1} \left(\frac{1}{2.42} \right) = 24.41^\circ$

7. What is the critical angle for light passing from glass into water?

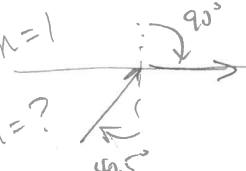
$n = 1.33$
 $n = 1.55$



$1.55 \sin \theta_c = 1.33 \sin 90$
 $\theta_c = \sin^{-1} \left(\frac{1.33}{1.55} \right) = 59.10^\circ$

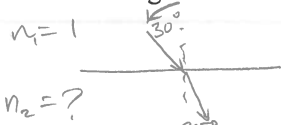
8. The critical angle for light passing from rock salt into air is 40.5 degrees. Calculate the index of refraction of rock salt.

$n = 1$
 $n = ?$



$n_1 \sin(40.5) = 1 \sin 90$
 $n_1 = \frac{1}{\sin(40.5)} = 1.54$

9. A beam of light enters a liquid of unknown composition from air at an angle of incidence of 30 degrees and is deflected by 5 degrees from its original path. Find the index of refraction.



$$n_1 \sin \theta_i = n_2 \sin \theta_r$$

$$1 \cdot \sin 30^\circ = n_2 \sin 25^\circ$$

$$n_2 = \frac{\sin 30^\circ}{\sin 25^\circ} = 1.18$$

1.18

10. Paxton has a brilliant idea and decides to spear a fish using a laser sight. Using her considerable knowledge of physics she calculates her aim. If she hits the fish did she aim above, below or directly at the fish?



below

11. How long does it take a pulse of light to pass through a glass plate that is 6 cm thick?

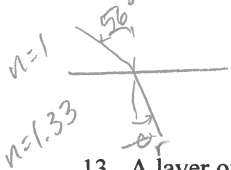
$$v = \frac{c}{n}$$

$$t = \frac{d}{v} = \frac{d \cdot n}{c}$$

$$t = \frac{(0.06)(1.55)}{3 \times 10^8} = 3.1 \times 10^{-10} \text{ s}$$

$3.1 \times 10^{-10} \text{ s}$

12. A flashlight beam is directed into water with an incidence angle of 56 degrees. Find the angle the beam makes in the water.



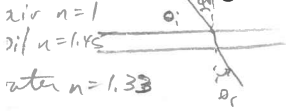
$$n_1 \sin \theta_i = n_2 \sin \theta_r$$

$$1 \cdot \sin 56^\circ = 1.33 \sin \theta_r$$

$$\theta_r = \sin^{-1} \left(\frac{\sin 56^\circ}{1.33} \right) = 38.56^\circ$$

38.56°

13. A layer of oil ($n = 1.45$) floats on water. A ray of light shines onto the oil from air and makes an angle of 40 degrees. Find the angle that the ray makes in the water.



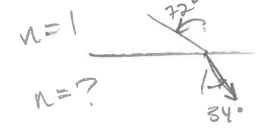
$$n_1 \sin \theta_1 = n_2 \sin \theta_2 = n_3 \sin \theta_3$$

$$1 \cdot \sin 40^\circ = 1.33 \sin \theta_3$$

$$\theta_3 = \sin^{-1} \left(\frac{\sin 40^\circ}{1.33} \right) = 28.9^\circ$$

28.9°

14. Extra dense flint glass has one of the highest indices of refraction of any type of glass. Suppose a beam of light passes from air into a block of extra dense flint glass. If the light has an angle of incidence of 72 degrees and an angle of refraction of 34 degrees, what is the index of refraction of the glass?



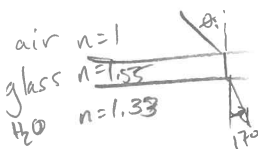
$$n_1 \sin \theta_i = n_2 \sin \theta_r$$

$$1 \cdot \sin 72^\circ = n \sin 34^\circ$$

$$n = \frac{\sin 72^\circ}{\sin 34^\circ} = 1.70$$

1.70

15. Someone on a glass-bottom boat shines a light through the glass into the water below. A scuba diver beneath the boat sees the light at an angle of 17 degrees with respect to the normal. If the glass's index of refraction is 1.5 and the water's index of refraction is 1.33, what is the angle of incidence with which the light passes from the air into the glass?



$$n_1 \sin \theta_1 = n_2 \sin \theta_2 = n_3 \sin \theta_3$$

$$1 \cdot \sin \theta_i = 1.33 \sin (17^\circ)$$

$$\theta_i = \sin^{-1} (1.33 \sin (17^\circ)) = 22.88^\circ$$

22.88°

16. When light in air enters an opal mounted on a ring, it travels at a speed of $2.07 \times 10^8 \text{ m/s}$. What is opal's index of refraction?

$$n = \frac{c}{v} = \frac{3 \times 10^8}{2.07 \times 10^8} = 1.45$$

1.45

17. A British company makes optical fibers that are 13.6 km in length. If the critical angle for the fibers in air is 42.1 degrees, what is the index of refraction of the fiber material?

$$\sin \theta_c = \frac{n_2}{n_1}$$

$$n_1 = \frac{n_2}{\sin \theta_c} = \frac{1}{\sin (42.1^\circ)} = 1.49$$

1.49

18. Find the critical angle for light traveling from blue topaz ($n = 1.61$) into air.

$$n_1 = 1.61$$

$$n_2 = 1$$

$$\theta_c = \sin^{-1} \left(\frac{1}{1.61} \right) = 38.40^\circ$$

38.40°