

# Snell's Law & Critical Angle Practice

1.  $n_1 = \text{air} = 1.0003$   
 $n_2 = \text{Water} = 1.33$   
 $\theta_1 = 35^\circ$   
 $\theta_2 = ?$

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

$$\sin^{-1} \left( \frac{n_1 \sin \theta_1}{n_2} \right) = \theta_2$$

$$\sin^{-1} \left( \frac{1.0003 (\sin 35)}{1.33} \right) = \theta_2$$

$$\sin^{-1}(0.4314) = \theta_2$$

$$\theta_2 = 25.55$$

$$\boxed{\theta_2 = 26^\circ}$$

2.  $\theta_1 = 18.5^\circ$   
 $\theta_2 = 12.0^\circ$   
 $n_1 = 1.0003$  air  
 $n_2 = ?$  glass

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

$$\frac{n_1 \sin \theta_1}{\sin \theta_2} = n_2$$

$$\frac{1.0003 \sin(18.5)}{\sin(12.0)} = n_2$$

$$\boxed{n_2 = 1.53}$$

3.  $\theta_1 = 10.0^\circ$   
 $\theta_2 = ?$   
 $n_1 = 1.0003$  (assume air)  
 $n_2 = 2.42$  diamond

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

$$\sin^{-1} \left( \frac{n_1 \sin \theta_1}{n_2} \right) = \theta_2$$

$$\sin^{-1} \left( \frac{1.0003 \sin(10.0)}{2.42} \right) = \theta_2$$

$$\sin^{-1}(0.07178) = \theta_2$$

$$\theta_2 = \boxed{4.1^\circ}$$

4.  $n_1 = 1.0003$   
 $n_2 = 1.27$   
 $\theta_1 = ?$   
 $\theta_2 = 43^\circ$

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

$$\theta_1 = \sin^{-1} \left( \frac{n_2 \sin \theta_2}{n_1} \right)$$

$$\theta_1 = \sin^{-1} \left( \frac{1.27 \sin 43}{1.0003} \right)$$

$$\theta_1 = \sin^{-1}(.86588)$$

$$\boxed{\theta_1 = 60^\circ}$$

5.  $\theta_1 = 50^\circ$   
 $\theta_2 = 40^\circ$   
 $n_1 = 1.0003$   
 $n_2 = ?$

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

$$\frac{n_1 \sin \theta_1}{\sin \theta_2} = n_2$$

$$\frac{1.0003 (\sin 50)}{\sin 40} = n_2$$

$$\boxed{n_2 = 1.19}$$

6.  $n_1 = 1.33$  water  
 $n_2 = 1.63$  CS<sub>2</sub>  
 $\theta_1 = 30^\circ$   
 $\theta_2 = ?$

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

$$\sin^{-1} \left( \frac{n_1 \sin \theta_1}{n_2} \right) = \theta_2$$

$$\sin^{-1} \left( \frac{1.33 \sin 30}{1.63} \right) = \theta_2$$

$$\sin^{-1}(0.40798) = \theta_2$$

$$\boxed{\theta_2 = 24^\circ}$$

7.  $\theta_1 = 50^\circ$   
 $\theta_2 = 33^\circ$   
 $n_1 = 1.0003$   
 $n_2 = ?$

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

$$\frac{n_1 \sin \theta_1}{\sin \theta_2} = n_2$$

$$n_2 = \frac{1.0003 (\sin 50)}{\sin(33)}$$

$$n_2 = 1.41$$

8.  $\theta_1 = 90 - 40 \Rightarrow 50^\circ$  use angle w/ normal  
 $\theta_2 = ?$   
 $n_1 = 1.0003$   
 $n_2 = 1.50$

Do not need to calculate water since it is an equivalent ratio

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

$$\sin^{-1} \left( \frac{n_1 \sin \theta_1}{n_2} \right) = \theta_2$$

$$\sin^{-1} \left( \frac{1.0003 \sin 50}{1.50} \right) = \theta_2$$

$$\sin^{-1}(.5108) = \theta_2$$

$$\theta_2 = 30.7^\circ$$

9.  $\theta_1 = ?$   
 $\theta_2 = 90^\circ \Rightarrow$  critical angle yields  $90^\circ$  refraction

$n_1 = 1.0003$   
 $n_2 = 2.42$

\* Assuming air is incident  $n_1$  must be greater than  $n_2$

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

$$\theta_1 = \sin^{-1} \left( \frac{n_2 \sin \theta_2}{n_1} \right)$$

$$\theta_1 = \sin^{-1} \left( \frac{2.42}{1.0003} \cdot \sin 90 \right)$$

$$\theta_1 = \sin^{-1} \left( \frac{2.42}{1.0003} \right)$$

cannot calculate  $\sin^{-1}(>1)$

critical angle does not exist

10.  $n_1 = 1.0003$   
 $n_2 = 1.50$   
 $\theta_1 = ?$   
 $\theta_2 = 90^\circ$

\* assuming air is incident

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

$$\theta_1 = \sin^{-1} \left( \frac{n_2 \sin \theta_2}{n_1} \right)$$

$$\theta_1 = \sin^{-1} \left( \frac{1.50 \sin 90}{1.0003} \right)$$

No solution  $\theta_1 = \sin^{-1}(>1)$

critical angle does not exist

11.  $\theta_1 = 52.0^\circ$   
 $\theta_2 = 90^\circ$   
 $n_1 = 1.0003$   
 $n_2 = ?$

\* assuming air is incident

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

$$n_2 = \frac{n_1 \sin \theta_1}{\sin \theta_2} = \frac{1.0003 \sin 52.0}{\sin 90}$$

$$n_2 = 0.788 = 0.79$$

Alternate

9.

$n_1 = 2.42$  → diamond is incident

$$n_2 = 1.0003$$

$$\theta_1 = ?$$

$$\theta_2 = 90$$

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

$$\theta_1 = \sin^{-1} \left( \frac{n_2 \sin \theta_2}{n_1} \right) = \sin^{-1} \left( \frac{1.0003 \sin 90}{2.42} \right) = \boxed{24.4^\circ}$$

Alternate

10.

$n_1 = 1.500$  glass is incident

$$n_2 = 1.0003$$

$$\theta_1 = ?$$

$$\theta_2 = 90$$

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

$$\theta_1 = \sin^{-1} \left( \frac{1.0003 \sin 90}{1.500} \right) = \boxed{41.8^\circ}$$

Alternate

11.

$$n_1 = ?$$

$$n_2 = \text{air} = 1.0003$$

$$\theta_1 = 52.0$$

$$\theta_2 = 90^\circ$$

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

$$n_1 = \frac{n_2 \sin \theta_2}{\sin \theta_1} = \frac{1.0003 \sin 90}{\sin 52.0} = \boxed{1.27}$$