

# Refraction Worksheet

1) a)  $n = \frac{c}{v}$

$$1.33 = \frac{3 \times 10^8}{v}$$

$$v = \frac{3 \times 10^8}{1.33} = \boxed{2.26 \times 10^8 \text{ m/s}}$$

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

$$2.42 = \frac{3 \times 10^8}{v}$$

$$v = \frac{3 \times 10^8}{2.42} = \boxed{1.24 \times 10^8 \text{ m/s}}$$

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

$$1.51 = \frac{3 \times 10^8}{v}$$

$$v = \frac{3 \times 10^8}{1.51} = \boxed{1.99 \times 10^8 \text{ m/s}}$$

2) a)  $n = \frac{c}{v} = \frac{3 \times 10^8}{2.1 \times 10^8} = \boxed{1.43}$

b)  $n = \frac{c}{v} = \frac{3 \times 10^8}{1.5 \times 10^8} = \boxed{2.00}$

$$\textcircled{3} \quad a) \quad n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$(1) \quad \sin 25 = 1.33 \sin \theta_2$$

$$\theta_2 = \sin^{-1} \left( \frac{\sin 25}{1.33} \right)$$

$$\theta_2 = \boxed{18.5^\circ}$$

$$b) \quad n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$(1) \quad \sin 25 = 2.42 \sin \theta_2$$

$$\theta_2 = \sin^{-1} \left( \frac{\sin 25}{2.42} \right)$$

$$\theta_2 = \boxed{10.1^\circ}$$

$$c) \quad n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$(1) \quad \sin 25 = 1.51 \sin \theta_2$$

$$\theta_2 = \sin^{-1} \left( \frac{\sin 25}{1.51} \right)$$

$$\theta_2 = \boxed{16.3^\circ}$$

$\textcircled{4} \quad a) \quad$  Since  $\theta_r < \theta_i$ , the ray bent towards the normal. That means it slowed down.

$\therefore$  the second medium is more dense.

④ b)  $n_1 \sin \theta_1 = n_2 \sin \theta_2$

$(1.33) \sin 20 = n_2 \sin 15$

$n_2 = \frac{1.33 \sin 20}{\sin 15}$

$n_2 = \boxed{1.76}$

c) water

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

$v = \frac{c}{n} = \frac{3 \times 10^8}{1.33} = \boxed{2.26 \times 10^8 \text{ m/s}}$

Other

$v = \frac{c}{n} = \frac{3 \times 10^8}{1.76} = \boxed{1.71 \times 10^8 \text{ m/s}}$

⑤ a) Since  $\theta_r > \theta_i$ , it bent away from the normal. Thus, it sped up!

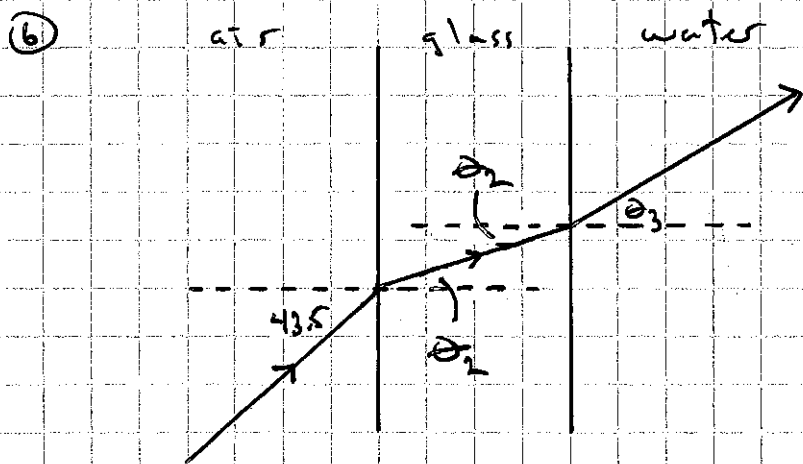
∴ the second medium is less dense!

b)  $1.33 \sin 20 = n_2 \sin 25$

$n_2 = \frac{1.33 \sin 20}{\sin 25} = \boxed{1.08}$

⑤ c) water  $2.26 \times 10^8$  m/s  
other

$$v = \frac{c}{n} = \frac{3 \times 10^8}{1.08} = \boxed{2.79 \times 10^8 \text{ m/s}}$$



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

(1)  $\sin 43.5 = 1.52 \sin \theta_2$

$$\theta_2 = \sin^{-1} \left( \frac{\sin 43.5}{1.52} \right) = \boxed{26.9^\circ}$$

b)  $n_2 \sin \theta_2 = n_3 \sin \theta_3$

$1.52 \sin 26.9 = 1.33 \sin \theta_3$

$$\theta_3 = \sin^{-1} \left( \frac{1.52 \sin 26.9}{1.33} \right)$$

$$\theta_3 = \boxed{31.2^\circ}$$

$$\textcircled{7} \quad \sin \theta_c = \frac{n_2}{n_1}$$

$$\sin \theta_c = \frac{1.33}{1.51}$$

$$\theta_c = \sin^{-1} \left( \frac{1.33}{1.51} \right) = \boxed{61.7^\circ}$$

Must start in the material with the higher index (Lucite).

$$\textcircled{8} \quad \sin \theta_c = \frac{n_2}{n_1}$$

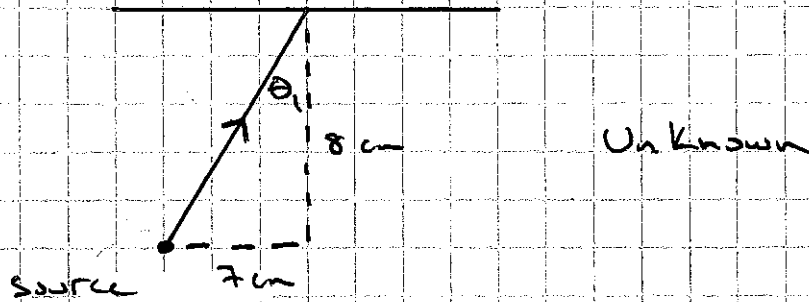
$$\sin 47.7 = \frac{1}{n_1}$$

$$n_1 = \frac{1}{\sin 47.7} = \boxed{1.35}$$

Note  $n_2 = 1$  because there is no lower index than 1, and the smallest index always goes on top.

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Air ( $n_2 = 1$ )



$$\tan \theta_1 = \frac{7}{8}$$

$$\theta_1 = \tan^{-1}\left(\frac{7}{8}\right) = 41.2^\circ$$

Since TIR occurs,  $\theta_c = 41.2^\circ$

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

$$\sin 41.2 = \frac{1}{n_1}$$

$$n_1 = \frac{1}{\sin 41.2} = \boxed{1.52}$$