Physics 102 Homework #5

first draft due Wednesday, February 18th
final draft due Sunday, March 5th

1a. A light ray with wavelength λ = 500 nm moves through air at speed 3x10^8 m/s. It then enters glass which has an index of refraction of n=1.53. What is the speed of light in this glass?

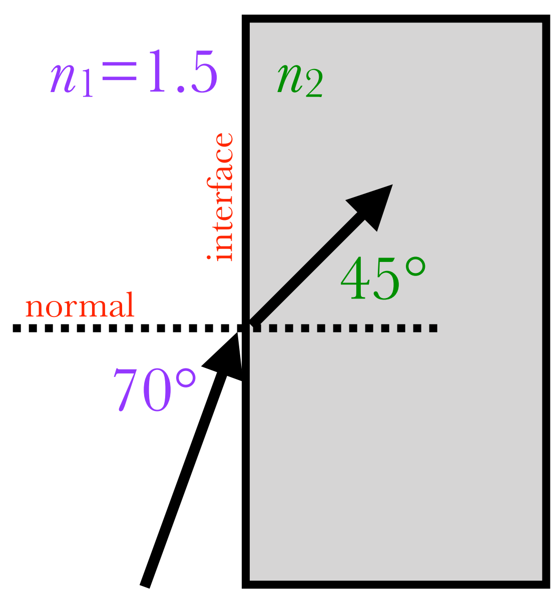
$$v = \frac{c}{n} = \frac{3 \times 10^8 \mathrm{m/s}}{1.53} = \mathbf{1.96 \times 10^8 m/s}$$

The λ is a red herring here; it doesn't matter to the solution.

1b. If light in a certain material moves at $9 \times 10^7 \mathrm{m/s}$, what would the material's index of refraction be?

$$n = \frac{c}{v} = \frac{3 \times 10^8 \mathrm{m/s}}{9 \times 10^7 \mathrm{m/s}} = \mathbf{3.33}$$

2. A ray of light in glass (n_1=1.5) enters another material (n_2) at a 70° angle; and emerges into the new material at a 45° angle. Find the index n_2.



We need to use Snell's Law here:

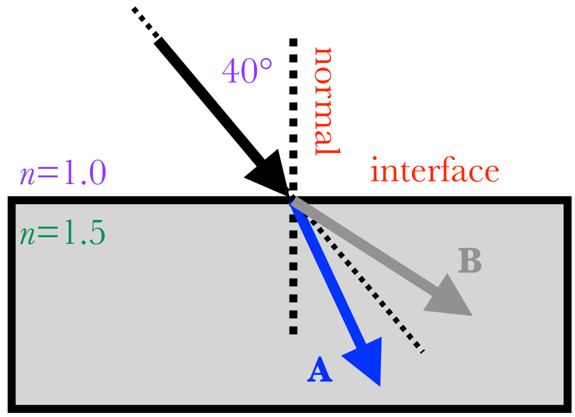
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\Longrightarrow \quad 1.50 \sin 70^\circ = n_2 \sin 45^\circ$$

$$\Longrightarrow \quad n_2 = 1.50 \frac{\sin 70^\circ}{\sin 45^\circ} = \mathbf{2.0.}$$

- If you had 1.36, you used radians instead of degrees. Careful!
- There seems to be some confusion as to which line is the normal.
- Also, make sure the index and the angle from a given material are on the same side of the equation.

3. A ray of light in air hits the surface of glass (n=1.5) at a 40° angle with respect to the normal. Find the angle between the normal and the ray that travels into the glass. Which of the rays shown, A or B, best represents the correct transmitted ray?



We need to use Snell's Law here:

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

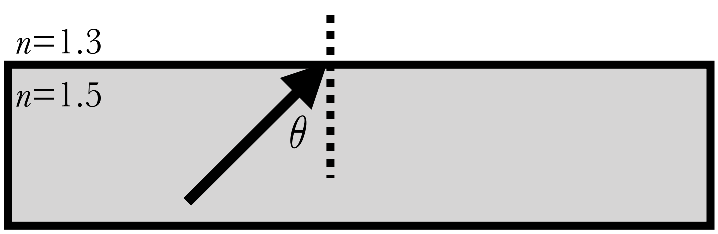
$$\Longrightarrow \; 1.0 \sin 40^\circ = 1.5 \sin\theta_2$$

$$\Longrightarrow \; \sin\theta_2 = \frac{1.0}{1.5}\sin 40^\circ = 0.4285$$

$$\Longrightarrow \; \theta_2 = \sin^{-1} 0.4285 = \mathbf{25.3^\circ} \text{ or } 0.44\text{rad.}$$

A bends towards the normal, since the index is higher (and the light is slower).

4. A ray of light travels in glass (n=1.5), and hits its interface with water (n=1.3). What is the maximum angle θ that the ray can make with the normal, and still pass through into the water.



We're looking for the critical angle:

$$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{1.3}{1.5}\right) = \mathbf{60^\circ} \text{ or } 1.05\text{rad.}$$

Any angle less than this will make it through, into the water.