Name _____ Date _____

PH 102 Quiz 7 SOLUTION

$n_1 \sin\theta_1 = n_2 \sin\theta_2$ $\quad n = \frac{c}{v}$ $\quad v = \lambda f$ $\quad c = 3 \times 10^8$ m/s $\quad E = hf = \frac{hc}{\lambda}$

1. In experimenting with a beam of white light and an acrylic prism, you found that the critical angle for total internal reflection for red light was *less* than that for blue light. What does this imply about the difference betwen the index of refraction for red and blue light (n_r and n_b, respectively) in the acrylic?

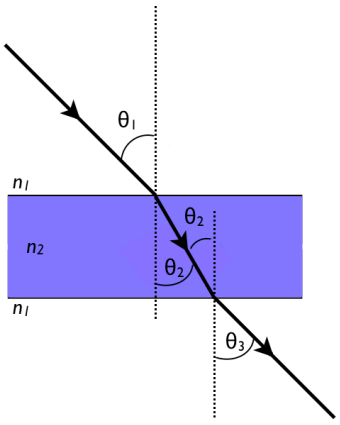
- ⊗ $n_r < n_b$
- ○ $n_b < n_r$
- ○ $n_r = n_b$
- ○ nothing, one also needs the wavelengths

The critical angle for total internal reflection is given by Snell's law: $n_{\text{prism}} \sin\theta_C = n_{\text{air}} \sin 90°$. Since the right side of this equation is the same for both red and blue light, we know that $n_{\text{prism, red}} \sin\theta_{C,red} = n_{\text{prism, blue}} \sin\theta_{C,blue}$, or the product $n_{\text{prism}} \sin\theta_C$ must be constant. Therefore, if the critical angle is *greater* for red light than for blue, then the sin of its angle must be also be *greater*, and the index of refraction for red light must be *smaller* for the product $n_{\text{prism}} \sin\theta_C$ to be the same for red and blue light.

2. As light travels from a vacuum ($n = 1$) to a medium such as glass ($n > 1$), which of the following properties remains the same?

- ○ wavelength
- ○ wave speed
- ⊗ frequency
- ○ none of the above

See the course notes or chapter 22 in Serway.



3. A light beam traveling through a transparent medium of index of refraction n_1 passes through a thick transparent slab with parallel faces and an index of refraction n_2. Which expression correctly gives the angle θ_3?

- ○ $\sin^{-1}(n_1 \sin\theta_2)$
- ○ θ_2
- ○ $\sin^{-1}(n_2 \sin\theta_2)$
- ⊗ θ_1

Apply the law of refraction twice, once at each interface. At the top interface, $n_1 \sin\theta_1 = n_2 \sin\theta_2$. At the bottom interface, $n_2 \sin\theta_2 = n_1 \sin\theta_3$. Therefore, $\sin\theta_1 = \sin\theta_3$ or $\theta_1 = \theta_3$.

4. If $n_1 = 1.0$ and $n_2 = 1.923$ in the figure above, what is θ_2 if $\theta_1 = 28°$?

⊗ 14°
○ 28°
○ 16°
○ 42°

Using the equations from the previous answer ... $\sin\theta_2 = \frac{n_1}{n_2}\sin\theta_1$. Plugging in the numbers given, one should get 14°.

5. If the thickness of the middle layer in the figure above is 2 cm (0.02 m), how long does it take for the light to pass through the transparent medium?

○ 7.2×10^{-11} s
○ 2.5×10^{-9} s
⊗ 1.3×10^{-10} s
○ 5.8×10^{-8} s

The time taken is simply the distance covered divided by the speed of light in medium 2. Let the thickness of the middle layer be d. Geometry tells us that the distance the light travels in medium 2 is $l = d/\cos\theta_2 \approx 0.021$ m. The speed of light in the medium is $v_2 = c/n_2 \approx 1.56 \times 10^8$ m/s, so the time taken is $l/v_2 \approx 1.3 \times 10^{-10}$ s.