Units? Units?

Name_____

Apr. 28, 2004

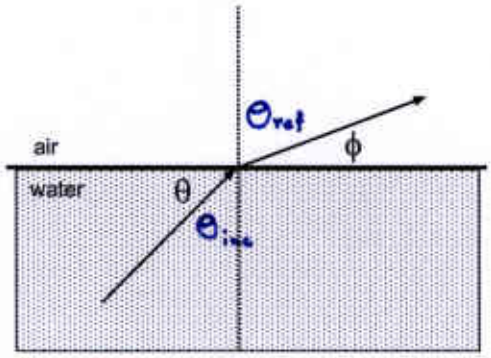
Phys 2020
Quiz #5 — Spring 2004

1. The index of refraction for water is 1.33. What is the speed of light in water?

Use $n = c/v$. Then:

$$v = \frac{c}{n} = \frac{(2.998\times10^8\ m/s)}{(1.33)} = \boxed{2.25\times10^8\ m/s}$$

2. A ray of light passes from water to air, as shown.



a) If the ray makes an angle of $\theta = 50.0°$ *with the surface of the water*, what angle does the emerging ray make with the surface of the water?

If θ is 50.0° then θ_{inc} (angle from normal) is 40.0°. Snell's law relates θ_{inc} and θ_{refr}! From $n_1 \sin\theta_1 = n_2 \sin\theta_2$ we get:

$(1.33)\sin 40.0° = (1.00)\sin\theta_{refr}$

$\rightarrow \sin\theta_{refr} = 0.855 \qquad \theta_{refr} = 58.7°$

From this we can get angle ϕ, which is what the problem is asking for:

$$\phi = 90° - \theta_{refr} = \boxed{31.3°}$$

b) How small can θ be before all of the light reflects back into the water?

As θ gets smaller, θ_{inc} gets bigger! Eventually θ_{inc} reaches the critical angle and then all the light is reflected back into the water. Here the critical angle is:

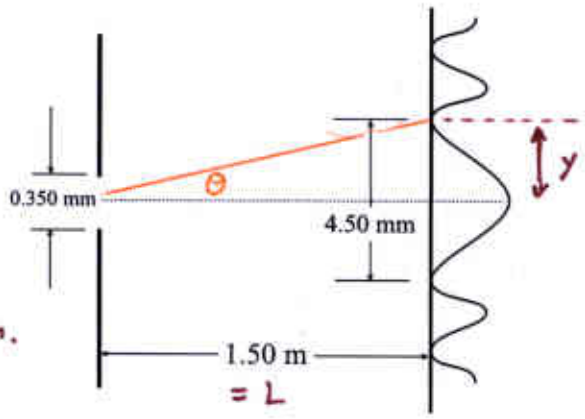
$$\sin\theta_{crit} = \frac{(1.00)}{(1.33)} \Rightarrow \theta_{crit} = 48.8°$$

So when θ_{inc} has this value then θ will have the value

$$\theta = 90° - 48.8° = \boxed{41.2°}$$

3. Coherent light passes through a slit of width 0.350 mm and strikes a screen 1.50 m away. It is found that the *full width* of the central bright spot of the diffraction pattern is 4.50 mm.

What is the wavelength of the light?



While the full width of the central bright fringe is 4.50 mm, the dist. from the center of the first dark fringe is $y = 2.25\,\text{mm}$.

Then $\tan\theta = \frac{y}{L} = 1.50\times10^{-3}$

and then we also have $\sin\theta = 1.50\times10^{-3}$.

Using $\sin\theta_{dark} = 1\cdot\frac{\lambda}{w}$ we set

$$\lambda = w\sin\theta = (0.350\times10^{-3}\,\text{m})(1.50\times10^{-3}) = 5.25\times10^{-7}\,\text{m},$$

or $\boxed{\lambda = 525\,\text{nm}}$

You must show all your work and include the right units with your answers!

$$n = \frac{c}{v} \qquad n_1\sin\theta_1 = n_2\sin\theta_2 \qquad \sin\theta_c = \frac{n_2}{n_1} \qquad c = 2.998\times10^8\,\frac{m}{s}$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$\sin\theta_{\text{bright}} = m\frac{\lambda}{d} \qquad \sin\theta_{\text{dark}} = (m+\tfrac{1}{2})\frac{\lambda}{d} \qquad m = 0, 1, 2, \ldots$$

$$\sin\theta_{\text{dark}} = m\frac{\lambda}{w} \qquad m = 1, 2, 3, \ldots$$

$$\lambda f = c \qquad E_{\text{photon}} = hf$$