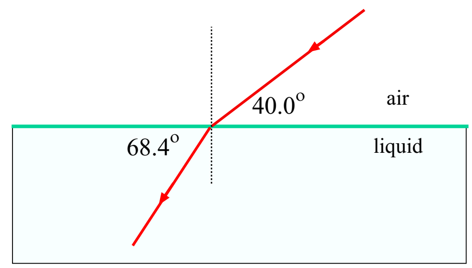
Name________________________________

Feb. 8, 2008

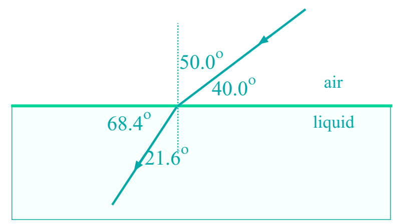
Quiz #1 — Spring 2008

Phys 2020



1. A beam of light is shone from air into some unknown liquid. The incoming beam makes and angle of 40° with the surface of the liquid. The refracted beam makes an angle of 68.4° with the surface.

a) Find the index of refraction of the liquid. *(Hint: Be careful with the way the angles are measured.)*



The angles that we will need for Snell's law are the ones that the rays make with the *normal* and these are 50.0° and 21.6°, as shown. The index of refraction for air is essentially $n_{\rm air} = 1.00$, so Snell's law gives

$$(1.00)\sin 50.0^\circ = n \sin 21.5^\circ$$

Solving for n,

$$n = \frac{\sin 50.0^\circ}{\sin 21.6^\circ} = 2.08$$

b) What is the speed of light in the liquid?

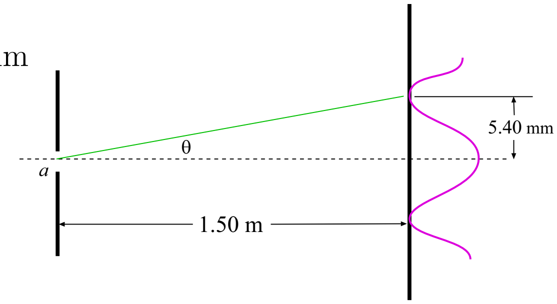
Use $n = \frac{c}{v}$, so that

$$v = \frac{c}{n} = \frac{3.00 \times 10^8 \, \frac{\rm m}{\rm s}}{2.08} = 1.44 \times 10^8 \, \frac{\rm m}{\rm s}$$

2. Give the meaning of the term *critical angle* as pertaining to light passing from medium 1 to medium 2, with $n_1 > n_2$.

When a ray goes from one medium into another where the index of refraction is less then there will some angle of incidence such that the refracted ray goes out at 90°. That angle of incidence is the critical angle for the two media. If the angle of incidence is greater than this, the ray will be reflected back within the first medium and *no* light will escape into the second medium.

3. In a single-slit diffraction experiment, monochromatic laser light is shone thru a slit of width 0.150 mm to give a pattern on a screen which is 1.50 m from the slit. In the resulting diffraction pattern, the distance between the first minimum and the central maximum is 5.40 mm.



a) What is the wavelength of the light?

The angle of the first minimum from the central maximum is:

$$\tan\theta_1 = \frac{5.40\times10^{-3}\ \mathrm{m}}{1.50\ \mathrm{m}} = 3.6\times10^{-3} \qquad \Longrightarrow \qquad \theta_1 = 0.206^\circ$$

Use this in the formula giving the angle of the diffraction minima:

$$\sin\theta_1 = (1)\frac{\lambda}{a} \qquad \Longrightarrow \qquad \lambda = (0.150\times10^{-3}\ \mathrm{m})\sin 0.206^\circ = 5.39\times10^{-7}\ \mathrm{m}$$

In the usual units of nanometers, this is

$$\lambda = 5.40\times10^{-7}\ \mathrm{m}\left(\frac{1\ \mathrm{nm}}{10^{-9}\ \mathrm{m}}\right) = 540\ \mathrm{nm}$$

b) Is this a plausible answer? How do you know?

The wavelength range of visible light goes from about $400\ \mathrm{nm}$ to $700\ \mathrm{nm}$, so this is a possible answer for the wavelength of visible light.

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

$$c = 3.00\times10^8\,\tfrac{\mathrm{m}}{\mathrm{s}} \qquad \text{Interference:} \quad \sin\theta_{\mathrm{br}} = m\frac{\lambda}{d} \qquad \text{Diffraction:} \quad \sin\theta_{\mathrm{dark}} = p\frac{\lambda}{a}$$

$$\lambda f = v \qquad n = \frac{c}{v} \qquad n_1\sin\theta_1 = n_2\sin\theta_2 \qquad \sin\theta_c = \frac{n_2}{n_1} \qquad \frac{1}{s}+\frac{1}{s'} = \frac{1}{f}$$