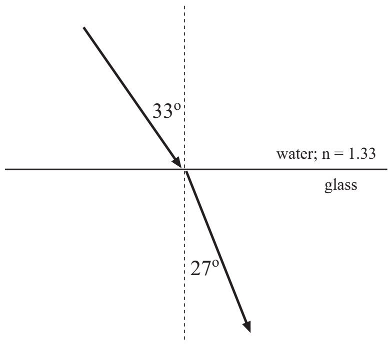
Name________________________

Apr. 19, 2006

Phys 2020, NSCC – Spring 2006
Quiz #3

1. A beam of light of (vacuum) wavelength 650 nm goes from water ($n = 1.33$) to glass with an angle of incidence of 33.0°. The beam enters the glass at an angle of 27.0° from the normal.



a) Find the index of refraction of the glass.

Use Snell's Law, $n_1 \sin\theta_1 = n_2 \sin\theta_2$, then

$$(1.33)\sin 33° = n_2 \sin 27°$$

Then

$$n_2 = \frac{(1.33)\sin 33°}{(\sin 27°)} = 1.60$$

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

Speed of light in the glass is

$$v = \frac{c}{n} = \frac{(3.00 \times 10^8\,\frac{\mathrm{m}}{\mathrm{s}})}{(1.60)} = 1.88 \times 10^8\,\frac{\mathrm{m}}{\mathrm{s}}$$

c) What is the wavelength of the light in the glass?

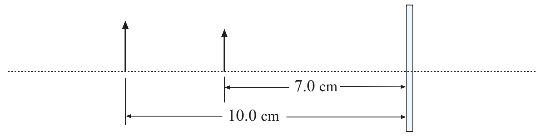
The *frequency* for the light is the same in all media, thought its speed and wavelength differ. The freuqency in any medium is $f = v/\lambda$, so

$$f = \frac{c}{\lambda_{\mathrm{vac}}} = \frac{v_{\mathrm{gl}}}{\lambda_{\mathrm{gl}}}$$

so

$$\lambda_{\mathrm{gl}} = \frac{v_{\mathrm{gl}}}{c}\lambda_{\mathrm{vac}} = \frac{(1.88 \times 10^8\,\frac{\mathrm{m}}{\mathrm{s}})}{(3.00 \times 10^8\,\frac{\mathrm{m}}{\mathrm{s}})}(650\ \mathrm{nm}) = 407\ \mathrm{nm}$$

2. An object is placed 10.0 cm in front of a lens. The lens forms an image 7.00 cm on the *same* (i.e. left) side of the lens. (In which case it *has* to be upright!)



What is the focal length of the lens? Is it a converging or diverging lens?

Here $d_o = 10.0\ \mathrm{cm}$ and $d_i = -7.0\ \mathrm{cm}$ so the lens equation gives

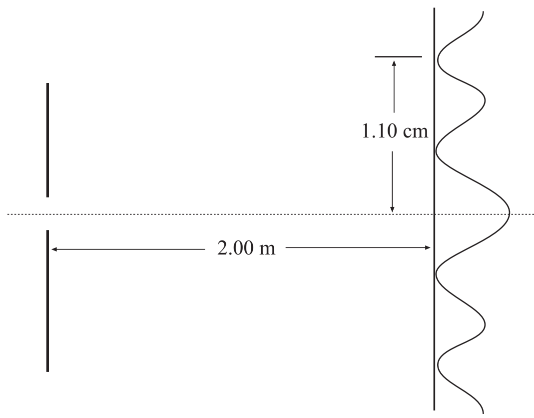
$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{10.0\ \mathrm{cm}} + \frac{1}{(-7.0\ \mathrm{cm})} = -4.29 \times 10^{-2}\ \mathrm{cm}^{-1} = \frac{1}{f}$$

so then

$$f = -23.3\ \mathrm{cm}$$

f is negative so the lens is a $\boxed{\text{diverging}}$ lens.

3. A beam of coherent monohromatic light is incident on a single slit of width 0.200 mm. It forms a diffraction pattern on a screen 2.00 m from (and parallel to) the slit. The second diffraction minimum (dark fringe) is 1.10 cm from the central maximum.



What is the wavelength of the light?

This is the *second* dark fringe in the diffraction pattern so use $m = 2$ in the $\sin\theta_{\mathrm{dk}}$ formula. Use

$$\tan\theta = \frac{(1.10 \times 10^{-2}\ \mathrm{m})}{(2.00\ \mathrm{m})} = 5.50 \times 10^{-3} \qquad \Longrightarrow \qquad \theta = 3.15 \times 10^{-1}\ \mathrm{deg}$$

The diffraction formula gives

$$\lambda = \frac{a\sin\theta}{m} = \frac{(0.200 \times 10^{-3}\ \mathrm{m})\sin(0.0315^\circ)}{2} = 5.50 \times 10^{-7}\ \mathrm{m} = 550\ \mathrm{nm}$$

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

$$v = \frac{c}{n} \qquad n_1 \sin\theta_1 = n_2 \sin\theta_2 \qquad c = 3.00 \times 10^8\,\tfrac{\mathrm{m}}{\mathrm{s}} \qquad \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad m = -\frac{d_i}{d_o} = \frac{h_i}{h_o}$$

$$\text{Interf:} \quad \sin\theta_{\mathrm{br}} = m\frac{\lambda}{d} \qquad \sin\theta_{\mathrm{dk}} = (m + \tfrac{1}{2})\frac{\lambda}{d} \qquad \text{Diff:} \quad \sin\theta_{\mathrm{dk}} = m\frac{\lambda}{a}$$