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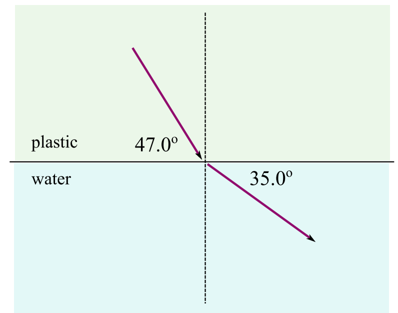
Nov. 28, 2012

Quiz #4 — Fall 2012

Phys 2120 – Sec 4



1. a) A light is incident from plastic to water; angles for the incident and refracted beams are as shown. (The index of refraction for water is 1.333.) Find the index of refraction for the plastic.

Hint: Be careful about which angles you use.

With medium 1 being the plastic and medium 2 being the water, we find the angles *measured from the normal* as

$$\theta_1 = 43.0^\circ \qquad \theta_2 = 55.0^\circ$$

Then Snell's law gives

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \qquad \Longrightarrow \qquad n_1 = n_2 \frac{\sin\theta_2}{\sin\theta_1} = (1.333)\frac{\sin 55^\circ}{\sin 43^\circ} = 1.60$$

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

Using $v = c/n$,

$$v = \frac{c}{n_1} = \frac{2.998 \times 10^8 \, \frac{\mathrm{m}}{\mathrm{s}}}{1.60} = 1.87 \times 10^8 \, \frac{\mathrm{m}}{\mathrm{s}}$$

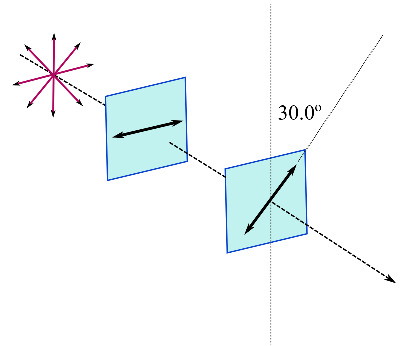
c) Is there a critical angle for light passing from plastic to water? If so, find it. Likewise, if there is a critical angle for light passing from water to plastic, find it.

For there to be a critical angle, the second medium must be optically *thinner* than the first one. Here the water is "thinner" than the plastic, so there will be a critical angle for light going from plastic, but not the other way. So in going from plastic to water we get

$$\sin\theta_c = \frac{n_2}{n_1} = \frac{1.333}{1.60} = 0.833 \qquad \Longrightarrow \qquad \theta_c = 56.4^\circ$$

2. Unpolarized light of intensity $\overline{S}_0$ is incident on a polarizing sheet whose axis is horizontal. The light then passes through a polarizer whose axis is 30.0° from the vertical.

Find the intensity of the light which emerges from the second polarizer.



The first polarizer reduces the intensity by a factor of $\frac{1}{2}$ and passes light which is polarized *horizontally*. The axis of second polarizer makes an angle of 60.0° with the direction of polarization of the light coming into it. Thus the second polarizer passes light polarized at this new angle and attenuated by a factor of $\cos^2(60.0^\circ)$. Combining all the factors attenuating the original beam the final intensity is

$$S = \frac{1}{2}\cos^2(60.0^\circ)\overline{S}_0 = \frac{1}{8}\overline{S}_0$$

3. An object is on the axis of a concave mirror of focal length 40.0 cm. Its distance from the mirror is 25.0 cm. Where is its image? Is it real or virtual?

Use the mirror equation, wherein we use

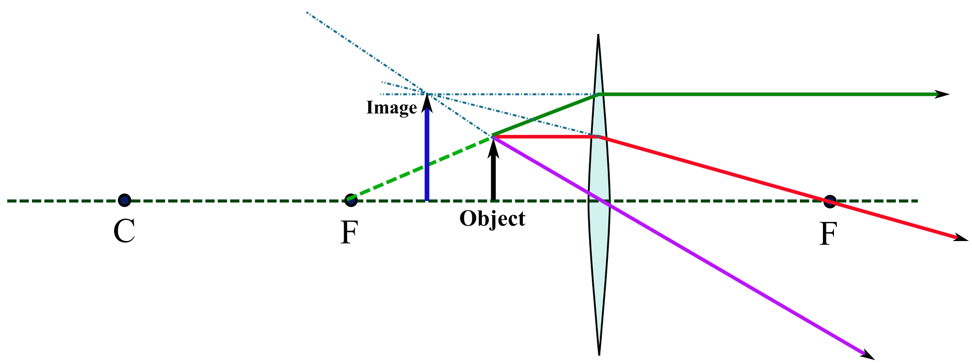
$$s = 25.0 \text{ cm} \qquad f = +40.0 \text{ cm}$$

Then

$$\frac{1}{s'} = \frac{1}{f} - \frac{1}{s} = \frac{1}{40.0 \text{ cm}} - \frac{1}{25.0 \text{ cm}} \qquad \Longrightarrow \qquad s' = -66.7 \text{ cm}$$

The image is 66.7 cm on the other side of the mirror. As the rays are not truly diverging outward from a point in space, the image is virtual.

4. On the diagram below a *convex* lens is shown along with its axis and focal points. An object is indicated.



Find the location and size of the image by means of ray tracing. No numbers are required here but your drawing should be as neat and clear as possible.

Rays are drawn here on the original figure: Through focal point then parallel; parallel then through focal point; through center of lens. Then they need to be continued *backwards* to get the point where they seem to come from. Image is a bit behind the object and larger. This is the "magnifying glass" configuration.

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

$$c = 2.998 \times 10^8 \,\tfrac{\text{m}}{\text{s}} \qquad \lambda f = c \qquad \overline{S} = \overline{S}_0 \cos^2\theta \qquad v = \frac{c}{n} \qquad n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\sin\theta_c = \frac{n_2}{n_1} \qquad \tan\theta_p = \frac{n_2}{n_1} \qquad \frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \qquad m = \frac{h'}{h} = -\frac{s'}{s}$$