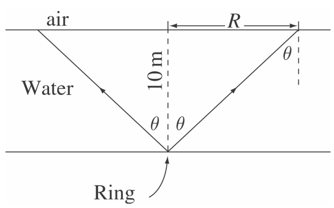
# Physics 203 – Principles of Physics III
# Homework Chapters 33 and 34
# Assignment #5 - April 22, 2008

**33-10:** a) $\theta_{water} = \arcsin\left(\dfrac{n_{air}}{n_{water}}\sin\theta_{air}\right) = \text{arsin}\left(\dfrac{1.00}{1.33}\sin 35.0^o\right) = 25.5^o.$

b) This calculation has not dependence on the glass because we can omit that step in the chain: $n_{air}\sin\theta_{air} = n_{glass}\sin\theta_{glass} = n_{water}\sin\theta_{water}$.

**33.16:**




If $\theta >$ critical angle, no light escapes,

so for the largest circle, $\theta = \theta_c$

$$n_w \sin\theta_c = n_{air}\sin 90° = (1.00)(1.00) = 1.00$$

$$\theta_c = \sin^{-1}(1/n_w) = \sin^{-1}\frac{1}{1.333} = 48.6°$$

$$\tan\theta_c = R/10.0\text{ m} \rightarrow R = (10.0\text{ m})\tan 48.6° = 11.3\text{ m}$$

$$A = \pi R^2 = \pi\,(13.3\text{ m})^2 = 401\text{ m}^2$$

**33-26:** a) $I = I_{max}\cos^2\phi \Rightarrow I = I_{max}\cos^2(22.5^o) = 0.854 I_{max}$.

b) $I = I_{max}\cos^2\phi \Rightarrow I = I_{max}\cos^2(45.0^o) = 0.500 I_{max}$.

c) $I = I_{max}\cos^2\phi \Rightarrow I = I_{max}\cos^2(67.5^o) = 0.146 I_{max}$.

**33-35:** Total internal reflection takes place at point A when the angle is determined as the critical angle given by $\sin\theta_C = \dfrac{n_a}{n_b}$. This angle is the complement of $\theta_b$, thus,

$$\theta_b = 90^\circ - \arcsin\left(\frac{n_a}{n_b}\right) = 90^\circ - \arcsin\left(\frac{1.00}{1.38}\right) = 43.6^\circ.$$

But $n_a \sin\theta_a = n_b\sin\theta_b \Rightarrow \theta_a = \arcsin\left(\dfrac{n_b\sin\theta_b}{n_a}\right) = \arcsin\left(\dfrac{1.38\sin(43.6^\circ)}{1.00}\right) = 72.1^\circ.$

**33-41:** The incident angle is determined by the geometry in air. The angle in the fluid is given by the geometry in the fluid, i.e.

$$\theta_a = \arctan\left(\frac{8.0\,cm}{16.0\,cm}\right) = 27^\circ \;\; and \;\; \theta_b = \arctan\left(\frac{4.0\,cm}{16.0\,cm}\right) = 14^\circ.$$

$$\text{So, } n_a \sin\theta_a = n_b \sin\theta_b \Rightarrow n_b = \left(\frac{n_a \sin\theta_a}{\sin\theta_b}\right) = \left(\frac{1.00 \sin 27^\circ}{\sin 14^\circ}\right) = 1.8.$$

**34-16:** a) $\frac{n_a}{s} + \frac{n_b}{s'} = 0 \Rightarrow \frac{1.33}{7.00\,cm} + \frac{1.00}{s'} = 0 \Rightarrow s' = -5.26$ cm, so the fish appears 5.26 cm below the surface viewed directly.

b) The fish is 13 cm from the mirror. The mirror image is thus at –13 cm behind the mirror or 33 cm below the surface of the water.

$\frac{n_a}{s} + \frac{n_b}{s'} = 0 \Rightarrow \frac{1.33}{33.0\,cm} + \frac{1.00}{s'} = 0 \Rightarrow s' = -24.8$ cm, so the image of the fish in the mirror appears 24.8 cm below the surface.

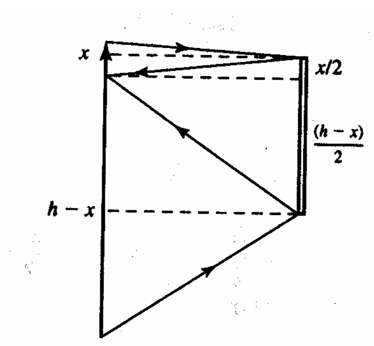
**34-28:** a) The magnification is $m = \frac{y'}{y} = 80 = \frac{s'}{s}$ thus

$s' = 80.0s$, and $s + s' = 6.00 \text{ m} \Rightarrow 81.00s = 6.00 \text{ m} \Rightarrow s = 0.0741 \text{ m}$ and $s' = 5.93$ m.

b) The image is inverted since both the image and object are real $(s' > 0, s > 0)$.

c) $\frac{1}{f} = \frac{1}{s} + \frac{1}{s'} = \frac{1}{0.0741\,m} + \frac{1}{5.93\,m} \Rightarrow f = 0.0732\,m,$ and the lens is converging.

**34-63** The minimum length mirror for a woman to see her full height *h*, is *h*/2, as shown in the figure below.

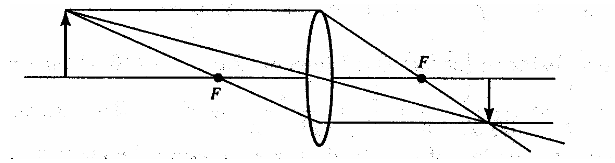



**34-70** The magnification is given by *m*=

$\frac{5}{2} = \frac{-s'}{s} \Rightarrow s = \frac{-2}{5}s' \Rightarrow \text{since } m < 0,\ s' < 0 \Rightarrow$ the image is virtual to the right

$$\text{Then } \frac{1}{s} + \frac{1}{s'} = \frac{1}{s} + \frac{2}{-5s} = \frac{2}{R} \Rightarrow s = \frac{3}{10}R \text{ and } s' = -\frac{3}{4}R$$

**34-94** Light passing straight through the lens:

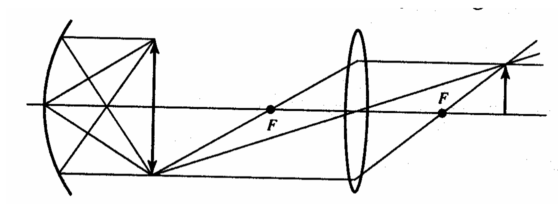



a) light from the candle directly through the lens forms a real, inverted image, as shown, at

$$\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}\Rightarrow\frac{1}{85.0cm}+\frac{1}{s'}=\frac{1}{32.0cm}\Rightarrow s'=51.3\text{ cm, to the right of the lens.}$$

For light reflecting off the mirror, the reflected image is real and inverted at the same position as the candle, i.e.

$$\frac{1}{\mathrm{s}}+\frac{1}{\mathrm{s}'}=\frac{1}{\mathrm{f}}\Rightarrow\frac{1}{20.0\mathrm{cm}}+\frac{1}{\mathrm{s}'}=\frac{1}{10.0\mathrm{cm}}\Rightarrow \mathrm{s}'=20.0\mathrm{cm}$$




This image becomes the new object for the lens. The image for this object is real and inverted. Thus, the final image is real and erect.

**34-96**a) With two lenses of different focal length in contact, the image distance from the first lens becomes exactly minus the object distance for the second lens. So we have:

$$\frac{1}{\mathrm{s}_1}+\frac{1}{\mathrm{s}_1'}=\frac{1}{\mathrm{f}_1}\Rightarrow\frac{1}{\mathrm{s}_1'}=\frac{1}{\mathrm{f}_1}-\frac{1}{\mathrm{s}_1}\quad\text{and}\quad\frac{1}{\mathrm{s}_2}+\frac{1}{\mathrm{s}_2'}=\frac{1}{\mathrm{f}_2}$$

$$\text{but } \mathrm{s}_2=-\mathrm{s}_1'\Rightarrow-\left(\frac{1}{\mathrm{f}_1}-\frac{1}{\mathrm{s}_1}\right)+\frac{1}{\mathrm{s}_2'}=\frac{1}{\mathrm{f}_2}\Rightarrow\frac{1}{\mathrm{s}_1}+\frac{1}{\mathrm{s}_2'}=\frac{1}{\mathrm{f}_1}+\frac{1}{\mathrm{f}_2}\Rightarrow\frac{1}{\mathrm{f}_{\text{combination}}}=\frac{1}{\mathrm{f}_1}+\frac{1}{\mathrm{f}_2}.$$

b) With carbon tetrachloride sitting in a meniscus lens, we have two lenses in contact. All we need in order to calculate the system's focal length is calculate the individual focal lengths, and then use the formula from part (a).

From the meniscus: $\frac{1}{f_m}=(n_b-n_a)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)=(0.55)\left(\frac{1}{4.50cm}-\frac{1}{9.00cm}\right)=0.061.$

For the $CCl_4$: $\frac{1}{f_\omega}=(n_b-n_a)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)=(0.46)\left(\frac{1}{9.00cm}-\frac{1}{\infty}\right)=0.051.$

$\Rightarrow\frac{1}{f}=\frac{1}{f_2}+\frac{1}{f_1}=0.112\Rightarrow f=8.93$ cm.