Phys 375 HW 3
Fall 2009
Due 5 / 6 October, 2009

1. Imagine that you are standing 5 feet from, and looking directly toward, a brass ball 1 foot in diameter hanging in front of a pawn shop. State the type of image, position, magnification, and whether it is upright or inverted.

Use the mirror equation $1/s_o+1/s_i = -2/R$, *with* $R = 0.5$ *ft. The sign convention for radius is negative here.* $1/s_i = -2/(0.5ft)-1/(5ft)$ *so* $s_i = -5/21 = -0.24$ *ft.* $M = -s_i/s_o = (-0.24)/5 = 0.048$. *The image is virtual, erect, and 0.048 times the object size.*

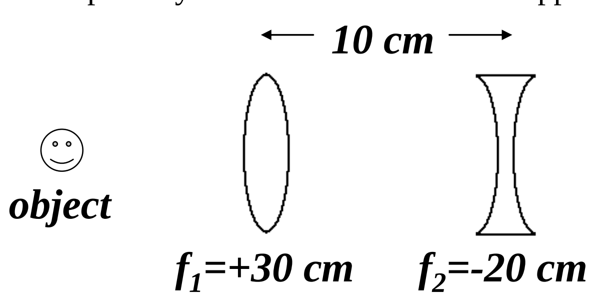
2. Design a little dentist's mirror to be fixed at the end of a shaft for use in the mouth of some happy soul. The requirements are (1) that the image be erect as seen by the dentist and (2) and that when held 1.5 cm from a tooth the mirror produces and image twice life-size.

The mirror must be concave to produce an upright, virtual image. $M = 2.0 = s_i/0.015$ *m implies* $s_i = -0.03$ *m. Putting into the mirror equation gives* $1/f = 1/0.015-1/0.03$ *so* $f = 0.03$ *m and* $R = 0.06$ *m.*

3. A candle that is 6.00 cm tall is standing 10 cm from a thin diverging lens whose focal length is -30 cm. Determine the location of the image and state the type of image, magnification, and whether it is upright or inverted.

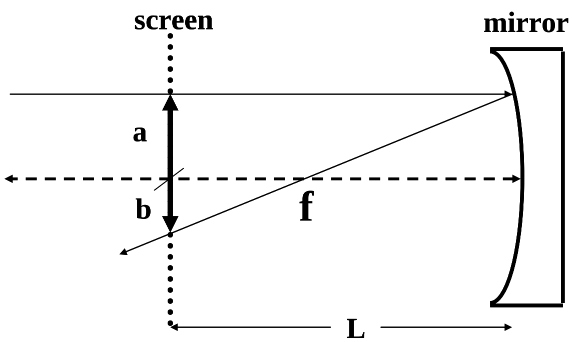
The lens equation $1/f = 1/s_o+1/s_i$ *implies* $1/s_i = 1/f - 1/s_o = -1/30-1/10 = -4/30$, *so* $s_i =- 7.5$ *cm.* $M = -s_i/s_o = 7.5/10 = ¾$. $(3/4)6.00 = 4.50$ *cm. The image is virtual, 7.5 cm in front of the lens and 4.50 cm tall.*

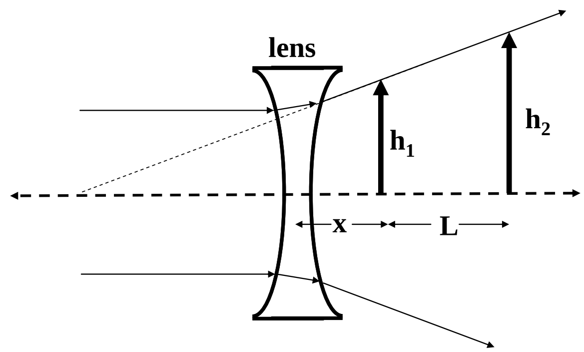
4. Compute the image location and magnification of an object 30 cm from the front lens of the thin lens combination shown in the figure. Do the calculation by finding the effect of each lens separately and make a sketch of the appropriate rays.



For the first lens $1/s_{i1} = 1/f - 1/s_{o1} = 1/30 - 1/30 = 0$, s_{i1} = *infinity.* s_{i1} *becomes* s_{o2} *at – infinity. Thus,* $1/s_{i2} = -1/20 + 1/\text{infinity} = -1/20$, $s_{i2} = -20$ *cm. The image is virtual and 10 cm in front of the first lens. The magnification of for the system is* $M = (s_{i1}/s_{o1})(s_{i2}/s_{o2})$ = *(-infinity/30)(20/-infinity) = 2/3.*

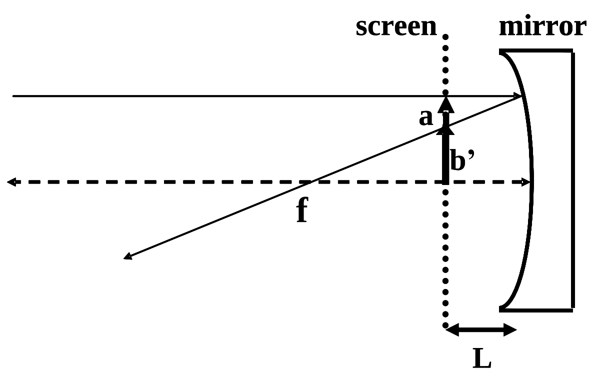
5. Using geometry and the diagram below left, calculate the focal length of the mirror in terms of a, b, and L for two cases: a) screen outside the focal length (as shown in the diagram), b) screen inside the focal length (figure shown further below).





a) *similar triangles implies* $\frac{a}{f} = \frac{b}{L-f}$ *, where f is the length from the mirror to the intersection of the reflected ray with the optic axis. Solving this equation for f gives* $\frac{aL}{a+b}$.

b) *similar triangles implies* $\frac{a}{f} = \frac{b'}{f-L}$. *Solving for f gives* $f = \frac{aL}{a-b'}$



6. Using geometry and the diagram above right, find the focal length of the diverging lens in terms of h_1, h_2, L and x.

Use the similar triangles created by h_1 *and* h_2. *This gives* $\frac{h_1}{x+f} = \frac{h_2}{x+L+f}$ *and*

$$f = \frac{(h_1 - h_2)x + h_1 L}{h_2 - h_1}$$