

## CLASS EXERCISE #19 - 20 July 2005

You are supposed to make a slide projector using a single convergent lens. The projector projects an image of a slide (which is placed near the lens, in the projector). Suppose you want the slide to be magnified 100 times (meaning  $|m| = 100$ ) and appear right-side up on a screen 5.0 m away from the projector lens.

Determine (in this suggested order):

- (a) the image distance  $i$  (including the correct sign),
- (b) the magnification  $m$  (including its correct sign),
- (c) the object distance  $o$  (including its correct sign), and
- (d) the approximate focal length of the lens you need.
- (e) Also, determine whether the slide (the object) needs to be upside-down or right-side up to give an image that is right-side up.

Since the image is to appear on a screen 5.0 m away from the lens,  $i = +5.0$  m. This must be positive since the image is real.

The absolute value of  $m$  is 100, for the image to be magnified 100 times. Is  $m = +100$  or  $-100$ ? Since  $i$  and  $o$  must be positive,  $m = -i/o$  must be negative, so the value of  $m$  must be  $m = -100$ .

Since  $m = -i/o$ ,  $o = -i/m = -(5.0 \text{ m})/(-100) = 0.050 \text{ m}$  or 5.0 cm. This is positive, as we expect, since the slide is a real object.

Then we can calculate the focal length from:

$$\begin{aligned} 1/f &= 1/i + 1/o = 1/(10.0 \text{ m}) + 1/(0.050 \text{ m}) \\ &= 0.100/\text{m} + 20.0/\text{m} = 20.1/\text{m} \end{aligned}$$

so  $f = 1 \text{ m}/20.1 = 0.050 \text{ m}$  or 5.0 cm (but just a little less).

Note that the slide must be placed just beyond the focal length:  $o$  is just a little greater than  $f$ . Since  $m$  is negative, the image is inverted, so for the image to be right-side up, the slide must be upside-down in the projector.