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 \(m = -i/o\), \(o = -i/m = -(5.0\) m)/(\(-100\)) = 0.050 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:

\[
1/f = 1/i + 1/o = 1/(10.0\) m\) + 1/(0.050\) m\)
\[
= 0.100/m + 20.0/m = 20.1/m
\]

so \(f = 1\) m/20.1 = 0.050 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.