PHYS 2020: College Physics
Manic Monday #5

"Computers are getting smarter all the time: scientists tell us that soon they will be able to talk to us. By 'they' I mean 'computers': I doubt scientists will ever be able to talk to us." ∼ Dave Barry

Geometrical Optics & the Real World[1]

Someday, you will leave physics far behind you, and will go off to lead a productive professional career. But as it happens, you will continue to encounter fundamental physics in your everyday lives. Suppose you become the director of technical support for the Acme Camera and Projector Company[2].

Your minions, who have had much less physics than you, are constantly coming to you with questions from customers about fine Acme products. Most of their problems can be resolved using simple ray tracing, or the basic equations of lenses:

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o} \qquad\qquad m = -\frac{d_i}{d_o}$$

Finally, you decide your minions need some practical optics training, so you devise a short exercise for them (this one!). Before you give it to them, however, you must make sure *you* know what the correct answers are.

A▷ACME Camera Lenses

A camera has a single lens which gathers light from distant objects, and produces a focused image inside the camera body, where the image is going to be recorded (either on film, or a digital CCD chip). For an object (*e.g.* a road runner, *accelerati incredibulis*) at a fixed distance from the camera, the exact properties of the lens determine the size of the image.

Consider the following question using *both* geometrical ray tracing, and mathematical application of the lens and magnification equations. If your approaches do not agree, explain which one is correct and why the other is wrong!

▷ Suppose a customer using a camera wants to have a *larger* image of a distant object than is being obtained with the lens currently in use. If the lens can be swapped out, should the new lens have a *longer* or *shorter* focal length?

B▷ACME Slide Projectors

In a projector, the lens produces a focused image a fixed distance away, on a screen. The object being imaged is inside the body of the projector (a slide or small digital screen), and the exact relationship to the lens determines the size of the final image.

Consider the following question using *both* geometrical ray tracing, and mathematical application of the lens and magnification equations. If your approaches do not agree, explain which one is correct and why the other is wrong!

▷ At a conference of southwestern predators, our customer (*appetitis giganticus*) is projecting his talk with a slide projector, and wishes to have a bigger image on the screen. The screen and projector are already on opposite ends of the room, so the only option is to change the lens. If the lens can be swapped out, should the new lens have a *longer* or *shorter* focal length?

C▷ACME Microscopes

Eventually, it becomes apparent that the optics division at ACME cannot survive on sales to coyotes along (though the explosives division is doing quite well), so you begin to manufacture microscopes in the hope that doctors and college students will want to own their very own quality ACME product.

[1] This problem was developed from a design by E. Redish of the University of Maryland Physics Education Research Group. `http://www.physics.umd.edu/perg/`

[2] Whose primary customers seems to be one Dr. W. E. Coyote, and one Dr. S. L. Larson.

A microscope works by combining two lenses. The first lens makes a magnified real image of an object. That real image is viewed through a second lens used as a magnifying lens to produce a further magnified virtual image – the image produced by the *first* lens is the object for the *second* lens.

In the figure below, you are attempting to look at a paramecium with your new microscope. The × marks are the focal points of the left hand lens, and the *o* marks are the focal points of the right hand lens. Draw a ray diagram showing the formation of the real and virtual images in the microscope. Two copies have been provided to help with clarity (transfer the *result* of one ray trace to the other).