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An Optics Investigation Using a Beaker

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An Optics Investigation Using a Beaker as a Cylindrical Lens

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Optics is amazing!

You are so excited to be teaching optics to your students and you have a brilliant laboratory all set up for them to investigate real and virtual images using thin lenses.

The students set up the lens and a lighted source, then they form a real image on a screen. Suitably amazed, you ask "if the screen is removed, is there any way to see the image?" The students jump all over this and tell you the screen is required. Then you have them look through the lens. Unfortunately, they are not impressed and simply state that the image is in a completely different place and is not the same as that formed on the screen.

"Blah," you think to yourself as you try to get them to find the image location using depth perception, after which, about a third of the students claim to believe you for image location.

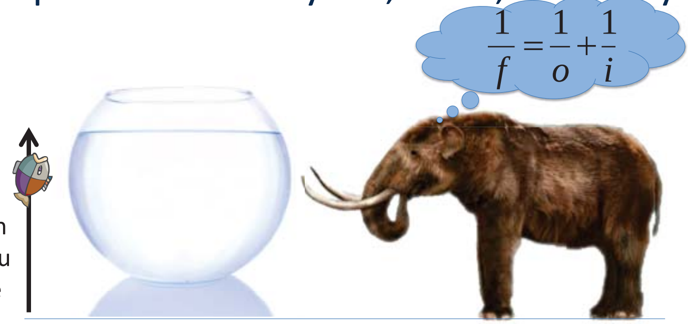
Later, you teach an intermediate optics class and the students have learned about spherical refracting surfaces. You know, the equation

$$\frac{n_2}{i}+\frac{n_1}{o}=\frac{(n_2-n_1)}{R}$$

where, the object is in a medium with index of refraction $\mathbf{n_1}$, a distance **o** from the surface of the refracting medium which has an index of refraction $\mathbf{n_2}$. The refracting medium has a radius of curvature **R**, and the image is located at **i**.

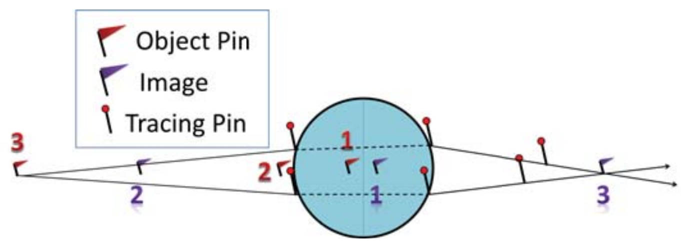
Assessing

When you give an assignment to the students in which they should apply this expression (like a fish bowl), the students insist on using the thin lens equation!

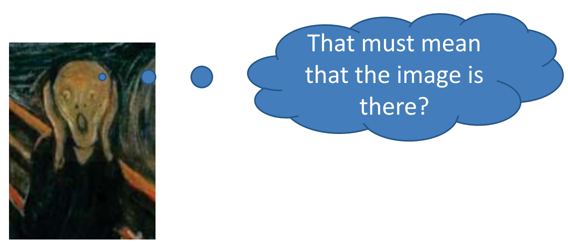


Solution?

So you pull out the old – use visual ray tracing through a beaker trick: Students experimentally determine the location of the image by lining up pins from source to beaker and then from the outside of the beaker (total of 6 pins and the source (usually a pin too!)). By tracing exiting rays to an intersection, the students determine the location of the image.

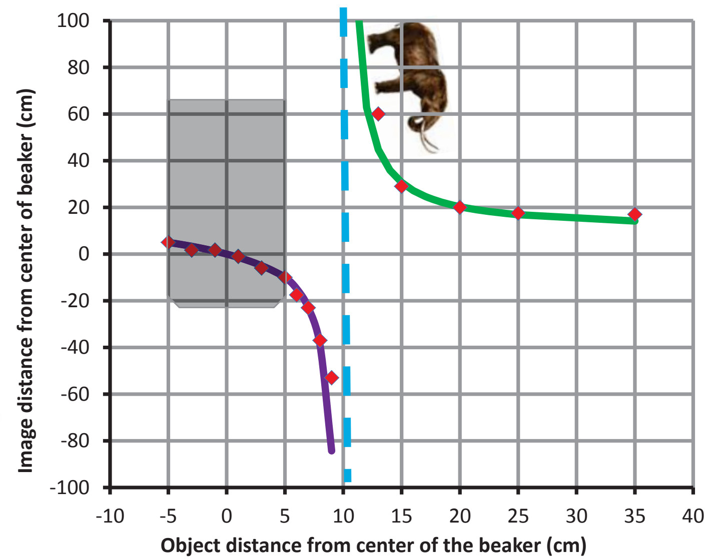


Starting with the source close to the beaker, students find the image is on the same side of the beaker as the object. Suddenly, they discover that the rays start to converge on the side of the beaker opposite the object! "How can that be? We must have done something wrong."



You also decide that the students can put the object inside the beaker. And to really help them get the idea, **they can determine** an expression describing the situation and compare it with the data.

$$\frac{1}{2R-\left[\frac{(n_2-n_1)}{R}-\frac{n_1}{s}\right]^{-1}}+\frac{n_1}{s''}=\frac{(n_1-n_2)}{R}$$



Plotting position of the image vs. position of the object leads to an interesting graph that can be modeled in a spread sheet using the expression above.

This simple investigation can help the students come to the inevitable conclusion that images can really be there and that the thin lens equation is not always best.

$$\frac{n_1}{s}+\frac{n_2}{s'}=\frac{(n_2-n_1)}{R}$$

$$\frac{n_2}{2R-s'}+\frac{n_1}{s''}=\frac{(n_1-n_2)}{R}$$

$$s'=\frac{1}{n_2}\frac{1}{\frac{(n_2-n_1)}{R}-\frac{n_1}{s}}$$

$$\frac{1}{2R-\frac{1}{\frac{(n_2-n_1)}{R}-\frac{n_1}{s}}}+\frac{n_1}{s''}=\frac{(n_1-n_2)}{R}$$