LASER CLASSROOM

Bringing STEM to light®

WATERDROP MICROSCOPE

BIG IDEAS

A simple set up turns a drop of pond water into a spherical lens to make visible the tiny world within. The effect is dramatic and makes an engaging introduction to lenses and geometric optics.

WHAT YOU'LL NEED

- Green LASER Blox
- Syringe
- Lab Stand
- Tape
- Blank Wall
- Pond, river, lake, stream or ocean water
- A steady hand and a little patience

RELATED PRODUCTS

Click the below to be taken right to the product page.

Green Laser Blox

Red & Green Laser Pointer

SETTING UP

To set up for this simple yet highly engaging demonstration, fill a syringe with water from a pond or river. If you live near a coast, get some sea water. If you are not near a pond or river or ocean, collect water from a puddle or some other standing body of water that is likely to have some tiny (0.2 - 0.5mm) organisms living in it.

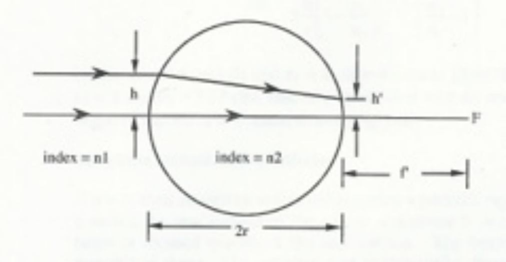
Fill a syringe with the collected water. Fix the syringe on a lab stand so that a drop of water hangs from the tip. Position the drop of water to line up with the beam of a green LASER Blox so that the beam passes through the center of the drop, perpendicular to the wall.

Your set up should be about two meters from a screen or plain white wall where a bright green spot will display an impressive array of single celled animals, larva, fleas, floating and swimming.

This is generally engaging enough to interest students in the powerful optics that makes this impressive sight possible.

BACKGROUND & DISCUSSION

For a drop of water, suspended from a syringe, as we have here, the figure to the right traces the path into and then out of the lens. The ray through the center does not deviate - all other rays, however, do bend towards the normal as they pass from air, index = n1, to water, index = n2.



A drop of water hanging from a syringe approximates a spherical lens, so we can apply the thick lens formula to determine the focal length.

For small angels, such as we have here, we use Snell's law - $n_1 \sin\theta_1 = n_2 \sin\theta_2$ becomes $n_1\theta_1 = n_2\theta_2$. So, the deviation toward the normal at one surface is given by:

$$\delta = \theta_1 - \theta_2 = \theta_1\left(1 - \frac{\theta_2}{\theta_1}\right) = \theta_1\left(1 - \frac{n_1}{n_2}\right)$$

This is a general equation used for very small angles, and is useful for tracing rays through complicated systems, which, despite our simple set up, is what we have here. For this example, the deviation as the ray passes from the air into our drop (the first surface), is

$$\delta = \frac{h}{r}\left(1 - \frac{n_1}{n_2}\right)$$

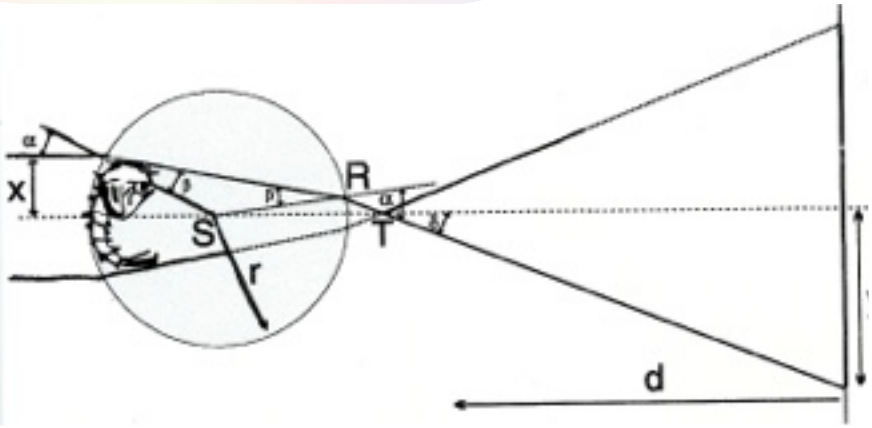
At the rear surface of the drop, the ray is closer to the axis by an amount 2r times the deviation - so it reaches the rear surface at distance h’

$$h' = h - 2r\delta = h - 2h\left(1 - \frac{n_1}{n_2}\right) = h\left(2\frac{n_1}{n_2} - 1\right)$$

The angle of deviation of the ray as it exits the drop is the same as the angle of deviation upon entering the drop. Finally -

$$f' = \frac{h'}{2\delta} = \frac{h\left(2\frac{n_1}{n_2} - 1\right)}{2\frac{h}{r}\left(1 - \frac{n_1}{n_2}\right)} = \frac{r}{2}\frac{\left(2 - \frac{n_2}{n_1}\right)}{\left(\frac{n_2}{n_1} - 1\right)}$$

Now, when you take at how this general phenomenon of light passing through a spherical lens creates the magnificent magnification before you, things get significantly more complicated and may be beyond the scope of high school students. The figure below is a simple ray diagram of the situation.



If you would like to explore the math behind this, please refer to the excellent paper by Gorazd Planinsic referred to at the beginning and end of this lesson.

Adapted from Gorzad Planinsic, Water-Drop Projector

http://www.fmf.uni-lj.si/~planinsic/articles/planin2.pdf

ACTIVITY SHEET: TRANSMISSION OF LIGHT

We're going to shine light through transparent gummy bears to see how light is reflected and transmitted.

1. Place each gummy bear on the white surface.
2. Shine the red LASER pointer through the each gummy bear in turn. You may have to hold it quite close to the gummy bear; not further than 2 cm away.

Does light pass through the red gummy bear? What color is it? Is any light reflected?

The light from the red LASER pointer passes through the red gummy bear. Some of the light might also be visibly reflected against the white surface. Does light pass through the green gummy bear? What color is it? Is any light reflected?

The red light does NOT pass through or reflect off the green gummy bear. This is because the green gummy bear absorbs red light, and transmits/reflects only green light.

Now, shine the white Lazr finger at each of the gummy bears. What do you notice about the white light when it passes through the red and green gummy bears?

The white light passes through both the red and green gummy bear, but appears as red and green, respectively. This is because the red gummy bear, for example, transmitted and reflected the red part of the white light (remember, white light consists of ALL the colors of light) but absorbed the rest of the wavelengths.

What do you notice about the all the results from the clear gummy bear, specifically? What do you notice about the black gummy bear, specifically?

The clear gummy bear allowed all of the lights to pass through it unchanged. It is completely transparent. The black gummy bear didn't allow any light to pass through it. This is because it absorbed ALL the wavelengths of light, and is opaque.