Saturday Morning Astrophysics at Purdue

Water Glass Lenses

Introduction

There are many kinds of, what we might generally refer to as "light," although most of them are not visible to humans. Radio waves, heat or infrared waves, ultraviolet waves, X-rays and microwaves are all the same sort of wave, but they differ by the length of the wave and, inversely, their frequency.

In this experiment you will learn about how light, when passing from one material to another, is slightly re-directed. In other words, the direction of its path changes, forming the basis for how lenses work. Observing these effects, you will experimentally be able to determine the focal length of a lens, created by a glass of water. The subject of light gives us the perfect opportunity for the curious to begin to explore the diverse subject of, you guessed it, physics!

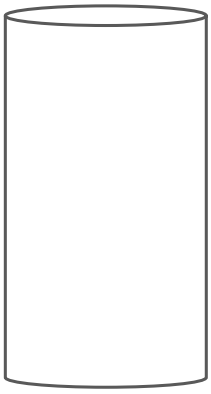
Check out the YouTube video introduction,

Materials

- Smooth clear water glass
- Cup of water
- Note card
- Markers (two colors optional)
- Ruler (cm markings)
- Support for the note card

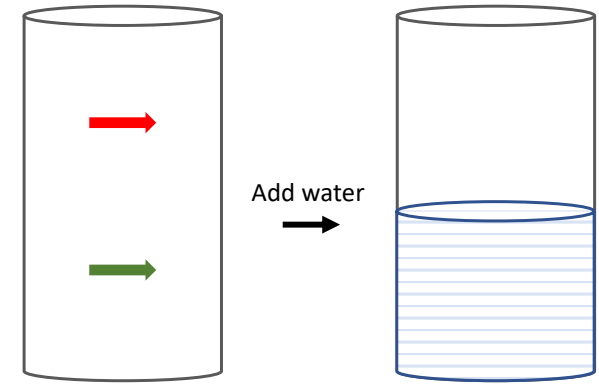
Part 1

1. Draw two small arrows (about 1 cm long) on a note card, spaced so that one would appear in the upper third of the water glass, the other in the lower third.
2. Place the empty water glass close to the edge of a table so you can look through it at eye level. Prop up the card with the arrows about 15 cm behind the glass.
3. Now, get down at eye level so you can look through the empty glass with your eyes at a level between the arrows.
4. In the glass to the right, draw how the arrows appear looking through the glass.
5. Are there any differences in the way the arrows appear, with or without the empty glass?



6. Now make a prediction.

   On the glass to the right, draw how you think the appearance of the arrows might change after you half fill the glass with water.

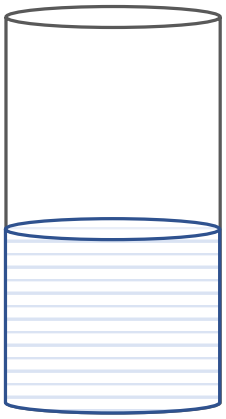


Appearance of arrows before adding water

Appearance of arrows after adding water

7. Now, keeping your eyes at the same level looking between the arrows, have your partner add water to the glass <u>just until</u> the water comes midway between the arrows.

8. Draw how the two arrows appear to you now.

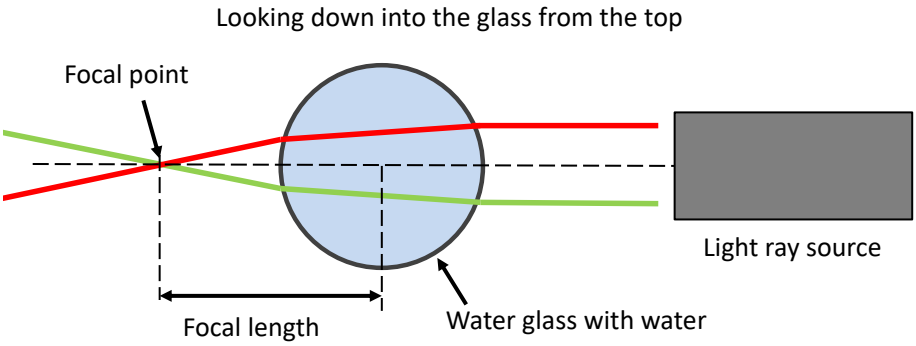


9. In what ways is the appearance of the bottom arrow different from how it appeared before you added water?

The water glass is changing the path or direction of the light waves. Light waves always travel in a straight line, unless they encounter something. When light waves pass through, around, or from one material to another, their direction of travel changes. Physicists would call this *refraction*, or put simply the "bending of light."

Every lens has a unique way of bending light, such that the light waves can either diverge (move apart) or converge (move together to a point at which the light waves cross).

The following diagram models how rays of light converge to a point.



10. How many times does each ray change direction?

11. Describe where each of these changes occurs.

Part 2

In Part 2, you will have the opportunity to locate and measure the focal length of your water glass lens.

1. Using the same set-up as before, with the water glass half filled, set the glass directly next to the arrow card.
2. Move the half-filled water glass back and forth slowly, until you see the bottom arrow reverse direction. Measure the space between the index card and the center of the water glass.
    a. What do you think you would you call the distance between card with the arrows, and the point where you can see the bottom arrow change direction looking through the glass?

    b. What do you think causes the image of the arrow reverse at this point?

    c. Draw a sketch to show your water glass, card with the arrows, and the focal point of your lens.