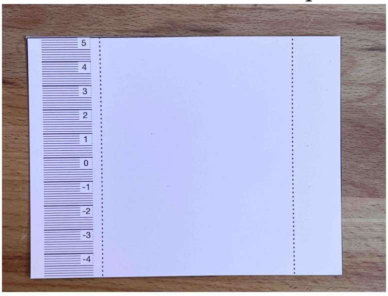
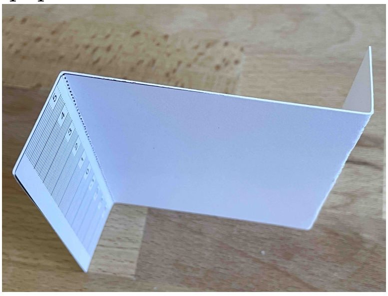
§ 1 Introduction

In this lab you will begin to see the geometric properties of the movement of light.

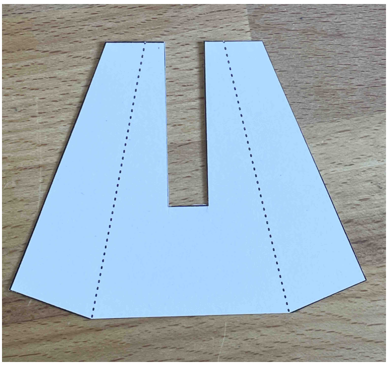
§ 2 Shadows

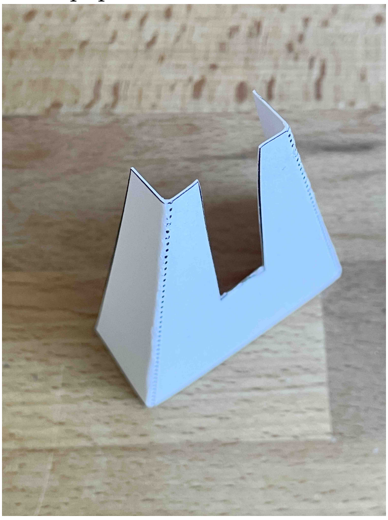
Cut out and fold the piece of paper that looks like this.



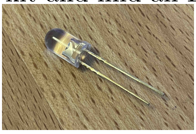


Cut out and fold the two pieces of paper that looks like this.

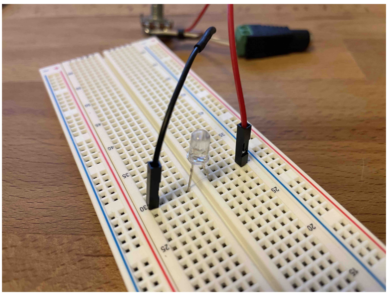




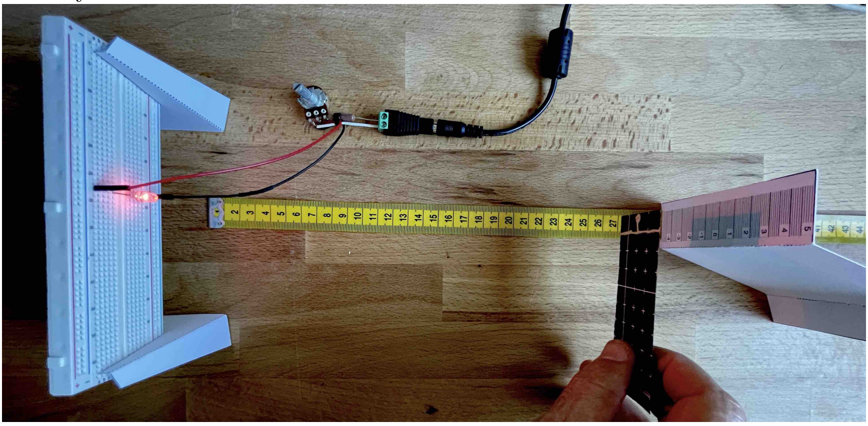
Look in the kit and find an LED.



Notice that one of the leads coming out the the LED is longer. Connect the longer lead to the red lead of the power supply and the shorter lead to the back lead of the power supply as shown in the image to the right.

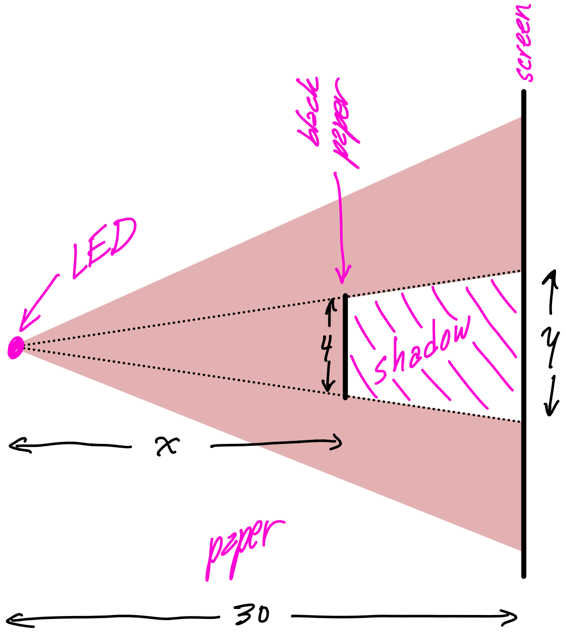


Next put the breadboard in the holder you folded and set up the tape measure and observing screen as shown, with the end of the tape measure directly under the LED and the observation screen at the 30 cm mark.



Use one of the 4cm wide pieces of black paper to make a shadow on the observation screen. Observe the sizes y of the shadow when the paper is at the locations x = 30cm, 24cm, 20cm, 15cm, and 12cm.

Use similar triangles to rationalize your measured results.

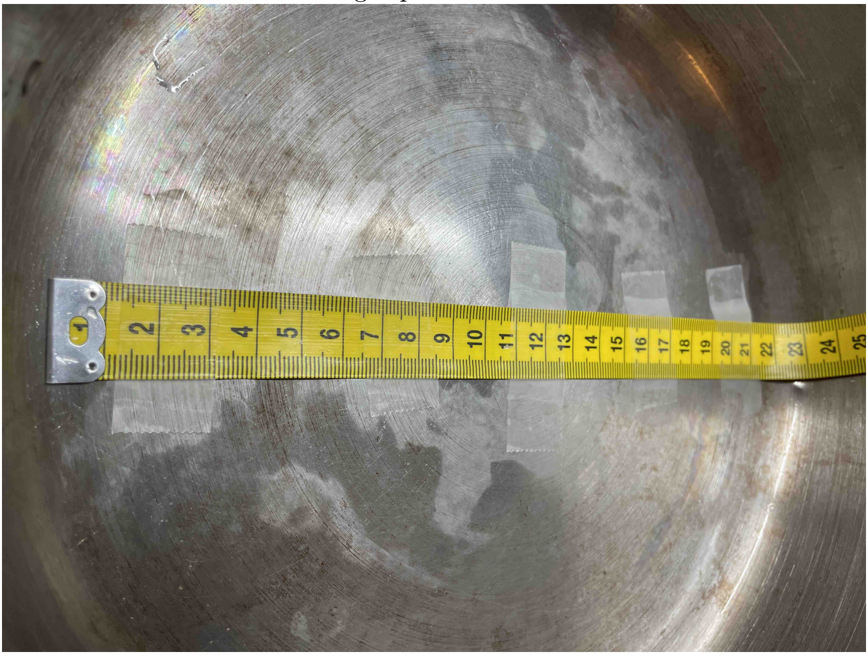


▷ QUESTION 1

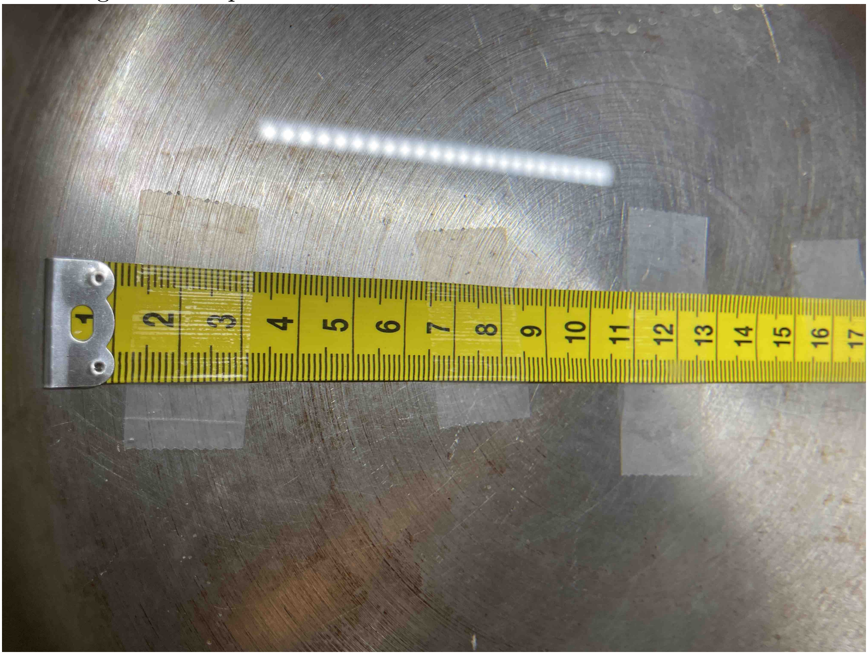
The similar triangles argument assumes that light travels in a straight line. Do your observations support the notion that light was traveling in a straight line when making the shadow?

§ 3 Snell's Law

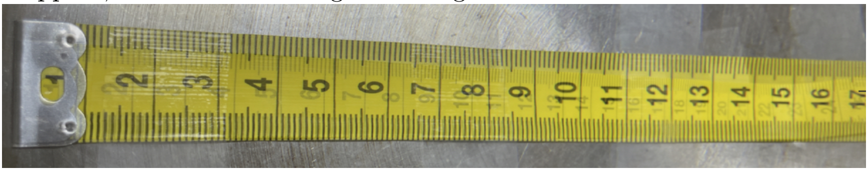
A camera was set up over an empty pot, and a photograph was taken. A tape measure can be seen taped to the bottom of the pot. The camera lens was directly over the end of the measuring tape and a height $h = 15.1\text{cm}$ above the end of the measuring tape.



Water was then added to the pot to a depth of $d = 11.2\text{cm}$, and another photograph was taken. Nothing about the camera was changed between this image and the previous.



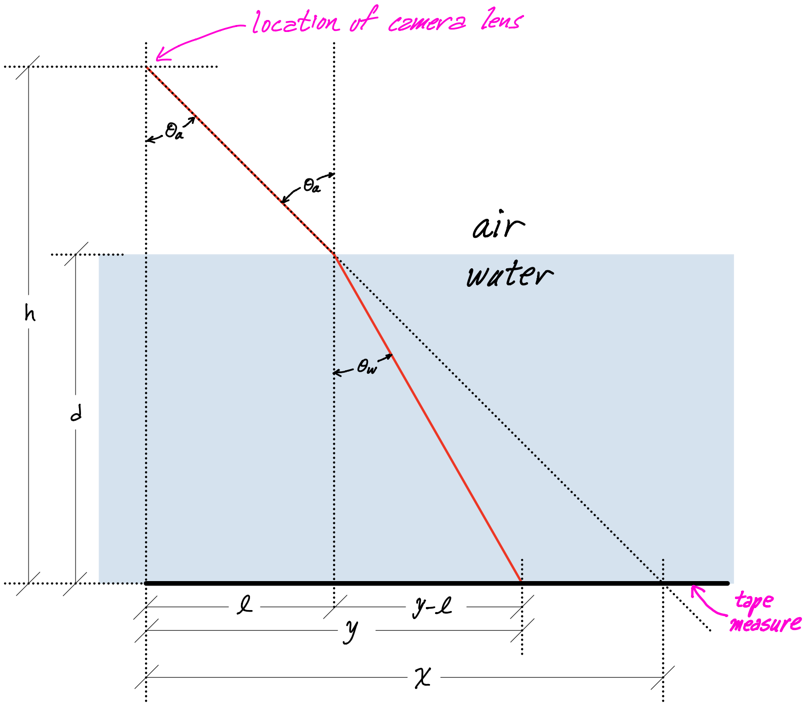
The following image is the two previous images superimposed and cropped , with the faint image the image without water.



§ 4 Analysis

Read the location on the with-water-tape-measure (the dark image) of the 2cm mark of the without-water-tape-measure (the faint image). You should get 1.7cm. Record the data pair $(x, y) = $ (2cm, 1.7cm). Repeat this for every faint centimeter mark up to 20cm. Notice that zero marks coincide in the super imposed image, so add the point (0cm, 0cm) to your data table also. Enter the data into a spread sheet.

Consider the following diagram, the red line shows the light coming from the tape measure at position y, changing directions as the surface of the water and going to the camera lens. The diagram also shows the position x that the camera saw in that same direction when the pot did not have water in it. So we can use the faint markings to measure the x and the dark markings to measure y.



Using the diagram prove the following relationships

$$\frac{\ell}{h-d} = \frac{x}{h} \qquad \text{so that} \qquad \ell = x\frac{h-d}{h}$$

$$\tan\theta_a = \frac{x}{h}$$

$$\tan\theta_w = \frac{y-\ell}{d} = \frac{y}{d} - x\left(\frac{1}{d} - \frac{1}{h}\right)$$

Using the spread sheet compute θ_a, θ_w, $\sin\theta_a$, and $\sin\theta_w$ from your measured values of x and y, and the given values of h and d. Then plot $\sin\theta_a$ versus $\sin\theta_w$, fit a straight line to the graph and find the slope of the best fit line.

▷ QUESTION 2

Snell's Law states that $n_a \sin\theta_a = n_w \sin\theta_w$ where n_a and n_w are the indexes of refraction for air and water. Does your data agree with Snell's Law?