§ 1 Introduction

In this lab you will form real and virtual images with a lens, practice using the thin lens equation and practice making ray diagrams.

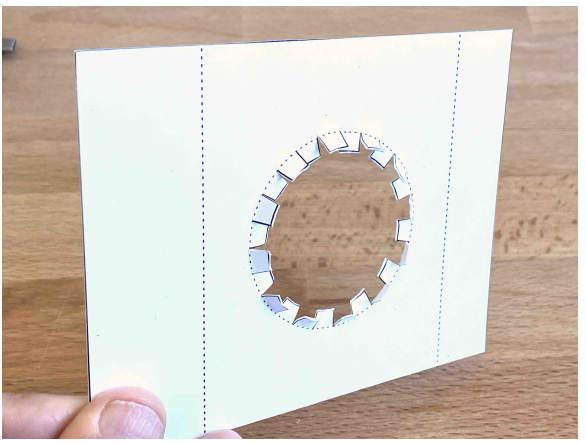
§ 2 Background

The thin lens equation relates the object and image distances to the focal length of the lens.

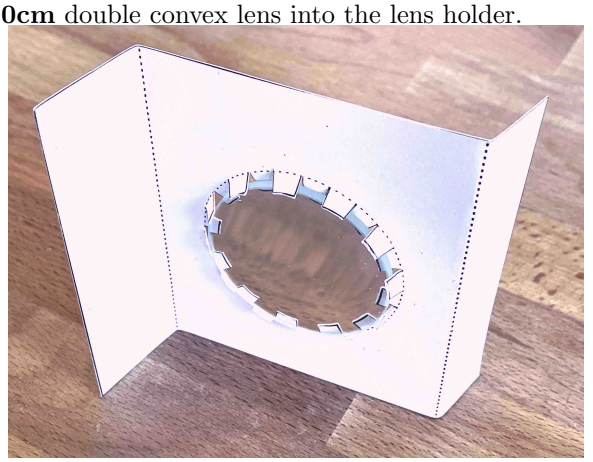
$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

§ 3 Setup

Cut out the lens holder, and bend every other the tabs as shown in the image below.

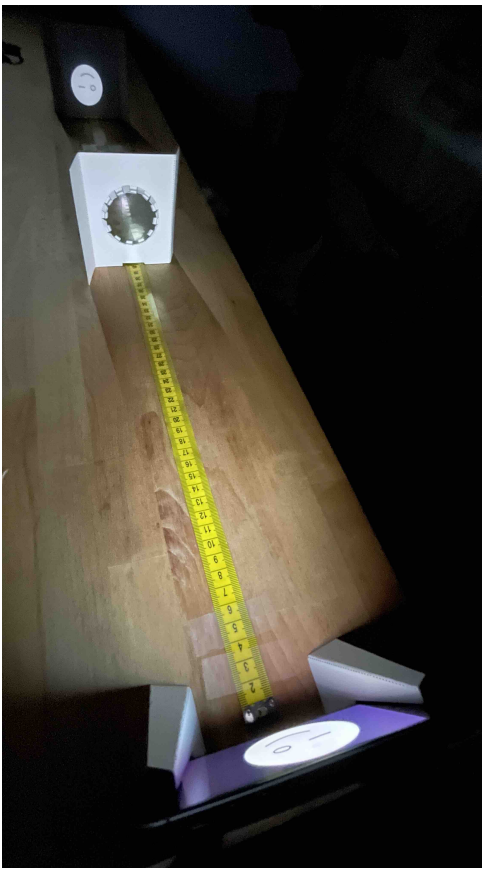


Insert the **20cm** double convex lens into the lens holder.



Now download this image, to your phone, and place the phone in the breadboard holder that you used last week. If you can't load the image onto a phone there is an alternative configuration explained at the end of this manual. You might need to modify the holder to fit your phone. In the end you want the center of the image to be 5 cm above the table. You will want to set your phone so that it does not go to sleep.

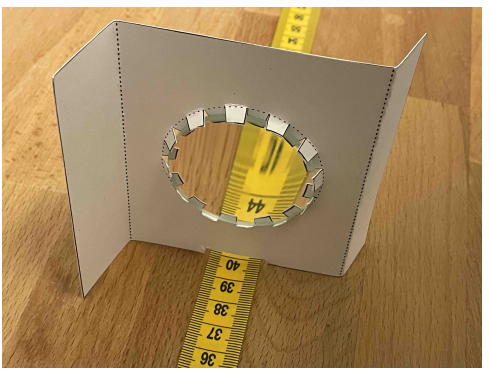
Find a surface that is at least 140cm long where you can set things up as shown to the right. First tape the tape measure to the surface so that it does not move.



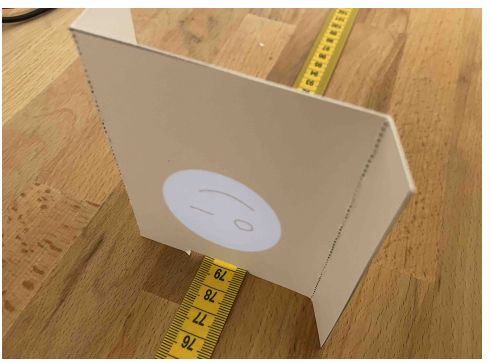
In this lab we will use the tape measure coordinate system, so $x = 37$cm will refer to the location on the tape measure marked 37cm.

Place the phone at $x = 0$.

Place the lens at $x = 40$cm. Notice that a small notch has been cut out of the bottom edge of the lens holder so that it straddles the tape measure without touching it.



Place the observation screen at $x = 80$cm. There is a notch in the observation screen too. Move the screen around until you find the location where the image is as sharp as possible. Record the location x_{lens} of the lens and the location x_{image} of the image .



Repeat with the lens at $x = 25$cm to 95cm every 5 cm. Get the application for this lab [macOS, MSwin] from the class website. Enter your image locations into the application, and save the pdf of the graph produced.

▷ Question 1

Based on your graph does the image location follow the thin lens equation. If so what is the focal length of your lens?

§ 4 Two converging lenses

Place the 20cm lens at $x = 40$cm and find the image of the winky face and put a marker on the tape measure at the location of the image. Mount the 30cm converging lens on top of the small wooden block as shown to the right using the modeling clay, so that the center of the lens is 5cm above the table. Without moving the 20cm lens place the 30cm lens at $x = 60$cm. Move the observation screen until you find the location of the screen that has the clearest image. Mark the location of the clearest image. Use the thin lens equation to compute the expected location of this final image.

▷ Question 2
Does your thin lens calculation of the location agree with the actual location.

▷ Question 3
Draw an accurate ray diagram for this configuration.

§ 5 Making a real image of a virtual image

Now mount the $f = -20$cm diverging lens on the wooden block instead. Place this lens at the 20cm mark on the tape measure. Use the thin lens equation to estimate the location of the virtual image formed by the lens. Verify that there is no real image formed by searching for it with the observation screen. Now place the 20cm converging lens at $x = 50$cm. Use the observation screen to find the location of the image of the virtual image. Use the thin lens equation to estimate the location of the virtual image from your observed location of the image of the virtual image.

▷ Question 4
Compare your two estimates of the location of the virtual image.

§ 6 Alternative to phone setup

In the case that you can't put the image on a phone, you can use four LEDs and the power supply to make a light source. The four diodes must be wired in series with the short lead of one LED connected to the long lead of the next LED in the series. The + power supply lead is connected to the long lead of the first LED and the - power supply lead connected to the short lead of the last LED.