§ 1 Introduction

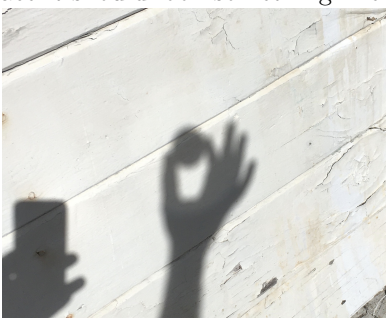
In this laboratory you will learn about lenses. Please send your work and answer to the problems to your lab instructor.

§ 2 The big picture

Go outside on a sunny day. You have been given some lenses. Some are thinner in the middle (concave) and some are thicker in the middle (convex).

(a) Make a shadow of your hand on a surface (the ground or a wall depending on the time of day). The shadow is a region that is not as brightly lit. The shadow of your hand is not as brightly lit because your hand is blocking the light that goes directly from the sun to that spot. The hand absorbs the light from the sun instead of it reaching the ground. The shadow is not completely dark because that region is also lit by other things, mostly the sky.

(b) Now make the shadow of your hand again but while holding a convex lens (use the one that is thicker in the middle). If your hand is at least two meters from the surface it should look something like this.



Notice that the lens is also casting a shadow! But the lens is clear, it does not absorb light like your hand does. So the question is, what happens to the light that hits the lens? In order to answer this question move your hand closer to the surface and watch carefully how the shadow and the region around the shadow changes. The changes will not be the same for the convex and concave lenses.

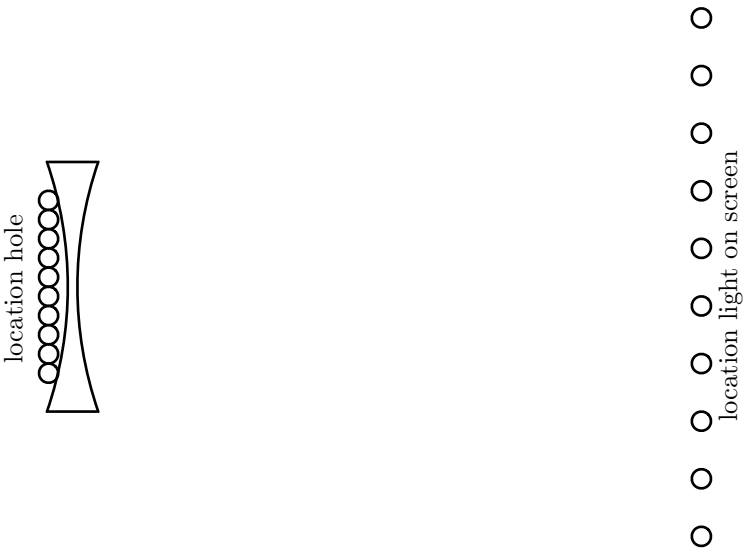
As you move your hand closer to the surface you should see things like in the examples below. You will not see all of the following examples with both types of lenses.

▷ Problem 1

Describe what happens to the light that hits the lens?

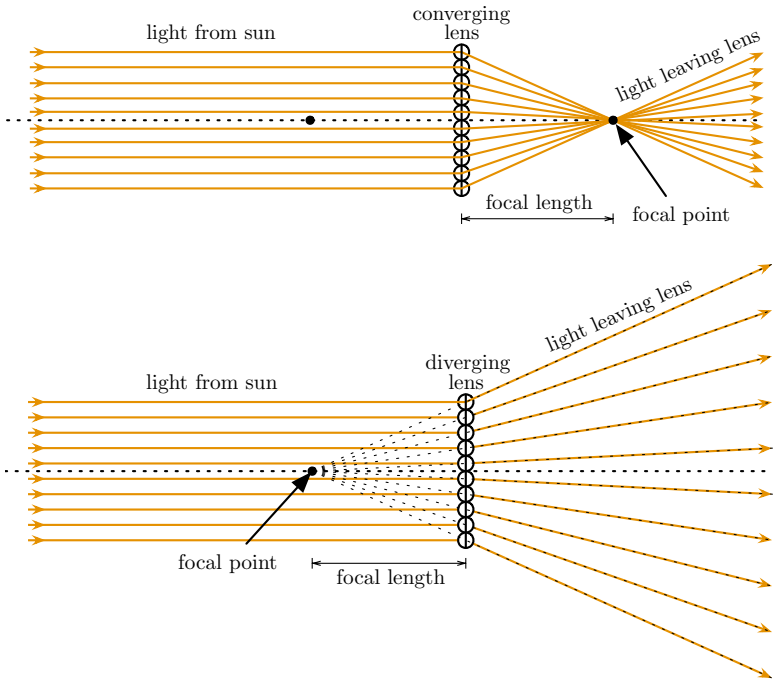
(c) Now make a 'screen' by making a 5mm in diameter hole in the middle of a piece of cardboard or aluminum foil that is about 10cm by 10cm. Again make a shadow of your hand holding the convex lens, with the lens about 1 meter from the surface. Now place the screen on the face of the lens so that all the light hitting the lens is blocked except what goes through the hole. Search for where the light going through this hole strikes the surface where the shadow is. As you move the hole over the lens observe how the light passing through the hole moves over the surface. Be sure not to move the lens as you move the hole. Keep moving the hole around until you think you understand the pattern. In the diagram below make a sketch of the pattern you observed by drawing a line from the location of the hole to the location of the light on the surface.

Repeat for the concave lense



§ 3 The detailed pattern

The group of rays coming from the sun strike the lens and change directions when they strike the lens. An ideal lens follows one of two patterns.



Notice that in the first case all the rays pass through a single point on the right, while in the second case all of the rays go to the right as if they all came from a point on the left. These points are called the focal points. The distance between the lens and the focal point is called the focal length f of the lens. For a diverging lens the focal length is considered to be negative for reasons that we will discover soon.

▷ Problem 2

Which of the above diagrams is for the convex lens?

(a) Now determine the focal length of your converging lens. This can be quickly done by moving the lens toward the observing surface until the bright spot in the middle is as small as possible. This occurs when the observation surface is at the focal point, thus the distance between the surface and the lens is the focal length.

(b) In order to determine the focal length of the diverging lens it is a little more complicated. In this case you adjust the distance between the lens and the surface until the bright ring around the shadow of the lens is twice as big in diameter as the lens. The distance to the surface is again the focal length.

▷ Problem 3

Why does this method of finding the focal length of the diverging lens work? You will need to use some geometric reasoning. A careful diagram should work.