LENSES & OPTICS OF THE EYE

**Credits:** Adaptation by Annette Lopez, Roger Key, Sarah Kroeker, California State University, Fresno Physics Dept.

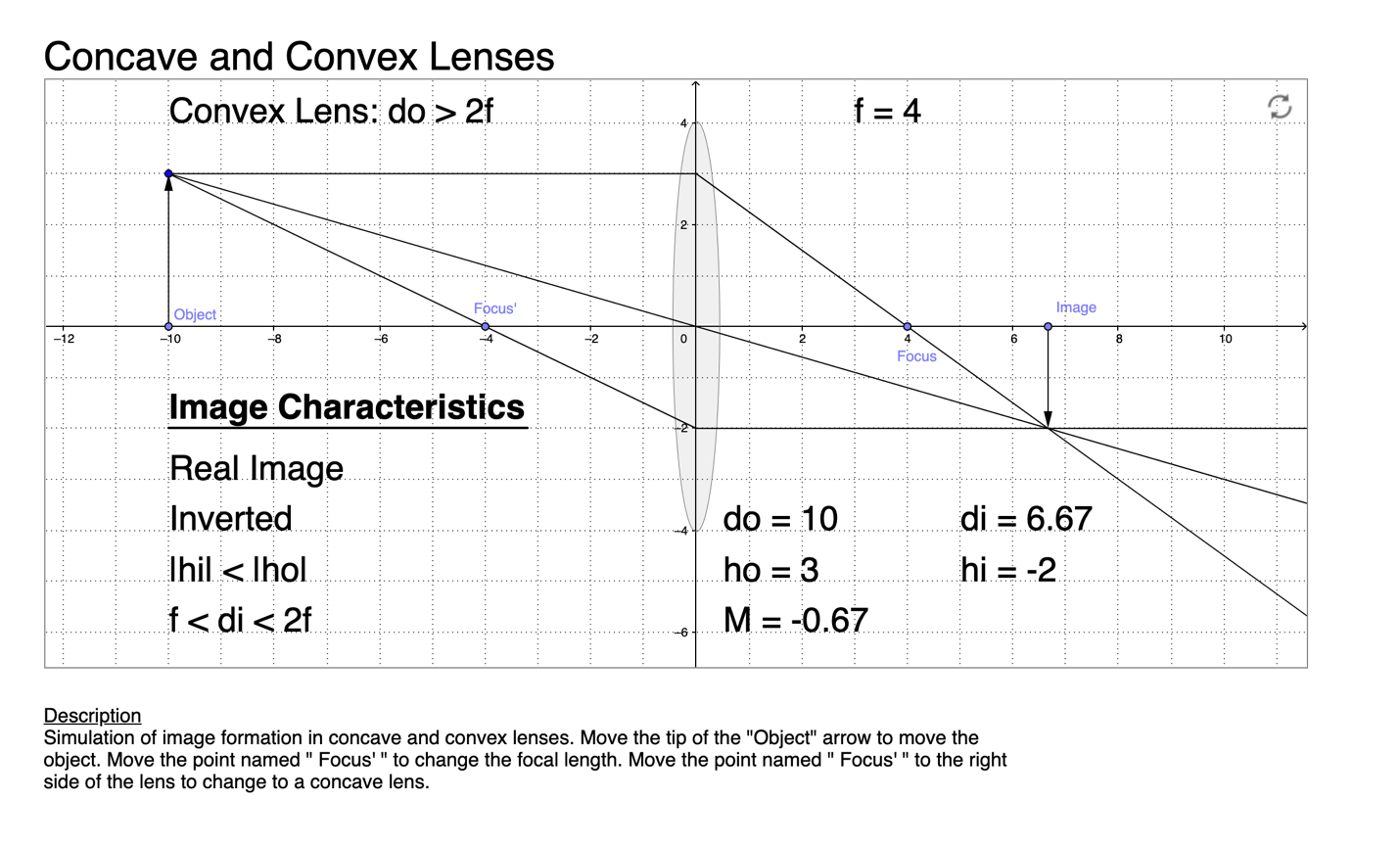
**Background:**

Read the introduction on page 79 of your paper lab manual. View these introductory videos:

* Crash Course Physics: <https://youtu.be/Oh4m8Ees-3Q>
* Bill Nye: <https://youtu.be/MvUIsetjVck>

**PART I: Lenses**

We will be using a simulation environment from oPhysics similar to the one use in Lab 08, however this time we have **lenses** instead of **mirrors**:



Link to simulation: <http://ophysics.com/l12.html>

**Instructions:**

For scale, each box will represent 1 cm. Use these units for your calculations.

**For converging lenses (Convex), the focal length is always positive, while diverging (Concave) lenses always have negative focal lengths**. Keep this in mind when doing your calculations. Also, when doing your calculations always make the given values of the **object distance positive**, they are written as negative to mimic the simulation.

Move the tip of the "Object" arrow/the blue circle to move the object.

**Make a note of the time when you are beginning this activity. Later, we want to know how much time you spent doing this activity.**

**1/f = 1/do + 1/di**

**Convex Lens**  *The Focus’ point should be to the left of the lens.*

1. Without the simulation, calculate the image position, height, and magnification for the following situation:

Focal length (f’) = -4 (+4 in your calculations)

Object distance (do) = –10 (+10 in your calculations)

Object height (ho) = 2 boxes 2 cm

Is the image real or virtual, is the image inverted or upright?

Mirror equation: 1/f = 1/do + 1/di 🡪 1/4 = 1/10 + 1/di 🡪 (1/4 - 1/10)^-1 = di

Di = 6.67 cm

Real = image distance is positive.

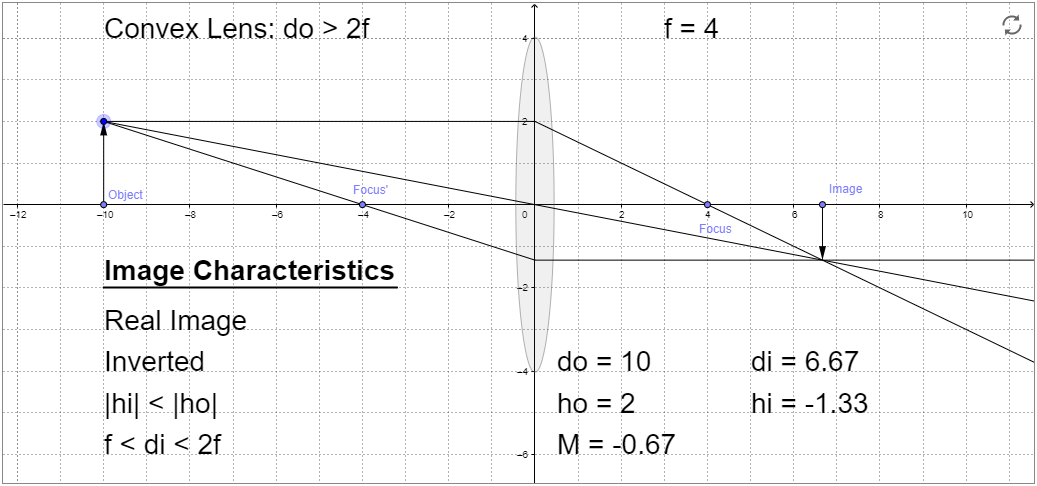
Virtual = image distance is negative.

Magnification equation: M = hi/ho = -di/do 🡪 hi/2 = -6.67/9 🡪 hi = 2\*6.67/10

Hi (image Height) = -1.33 cm

Inverted = height will be negative

1. In oPhysics (the simulation): Position the focus and object on the simulation to match the initial conditions in the previous question. Confirm that your answers were correct. If not, check your calculations. Reproduce the diagram below.



1. Without the simulation, calculate the image position, height, and magnification for the following situation:

Focal length (f’) = -4 (+4 in your calculations)

Object distance (do) = –6 (+6 in your calculations)

Object height (ho) = 2 boxes 2 cm

Is the image real or virtual, is the image inverted or upright?

Mirror equation: 1/f = 1/do + 1/di 🡪 1/4 = 1/6 + 1/di 🡪 (1/4 - 1/6)^-1 = di

Di = 12 cm

Real = image distance is positive.

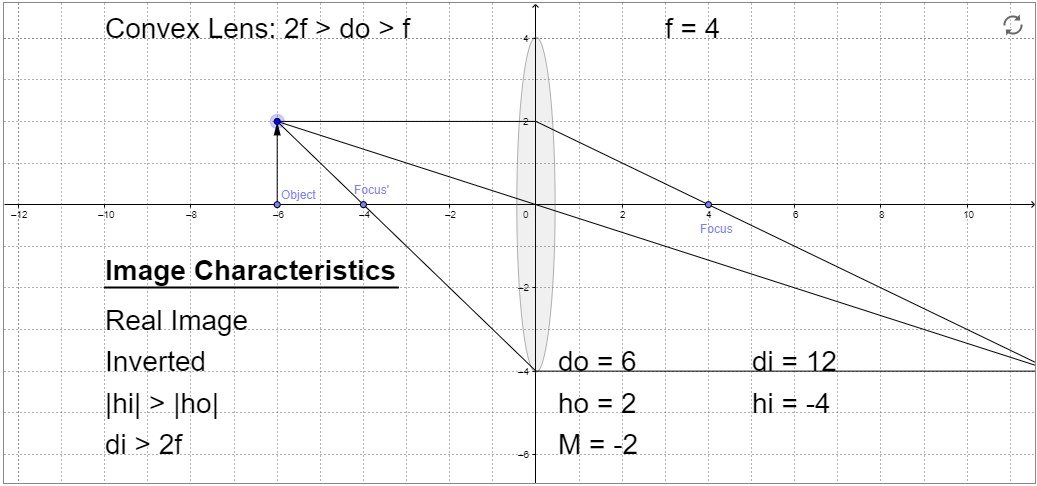
Virtual = image distance is negative.

Magnification equation: M = hi/ho = -di/do 🡪 hi/2 = -12/9 🡪 hi = 2\*12/6

Hi (image Height) = -4 cm

Inverted = height will be negative

1. In oPhysics (the simulation): Position the focus and object on the simulation to match the initial conditions in the previous question. Confirm that your answers were correct. If not, check your calculations. Reproduce the diagram below.



**Concave Lens**

*The Focus’ point should be to the right of the lens.* *You should see the lens shape change.*

1. Without the simulation, calculate the image position, height, and magnification for the following situation:

Focal length (f’) = +4 (-4 in your calculations)

Object distance (do) = –10 (+10 in your calculations)

Object height (ho) = 2 boxes 2 cm

Is the image real or virtual, is the image inverted or upright?

Mirror equation: 1/f = 1/do + 1/di 🡪 1/-4 = 1/10 + 1/di 🡪 (1/-4 - 1/10)^-1 = di

Di = -2.86 cm

Real = image distance is positive.

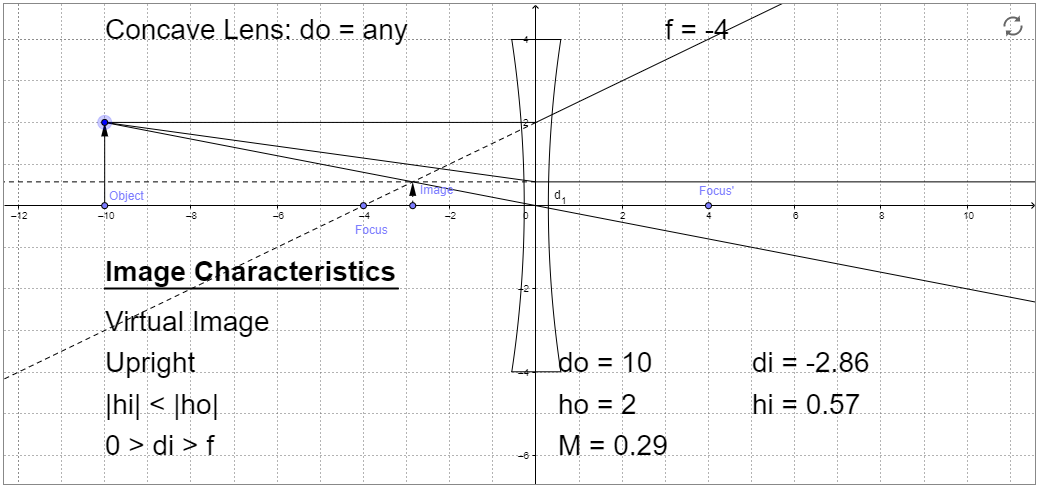
Virtual = image distance is negative.

Magnification equation: M = hi/ho = -di/do 🡪 hi/2 = -2.86/10 🡪 hi = 2\*2.86/10

Hi (image Height) = .57 cm

Upright = height will be Positive

1. In oPhysics (the simulation): Position the focus and object on the simulation to match the initial conditions in the previous question. Confirm that your answers were correct. If not, check your calculations. Reproduce the diagram below.



1. Without the simulation, calculate the image position, height, and magnification for the following situation:

Focal length (f) = +4 (-4 in your calculations)

Object distance (do) = –6 (+6 in your calculations)

Object height (ho) = 2 boxes

Is the image real or virtual, is the image inverted or upright?

Mirror equation: 1/f = 1/do + 1/di 🡪 1/-4 = 1/6 + 1/di 🡪 (1/-4 - 1/6)^-1 = di

Di = -2.4 cm

Real = image distance is positive.

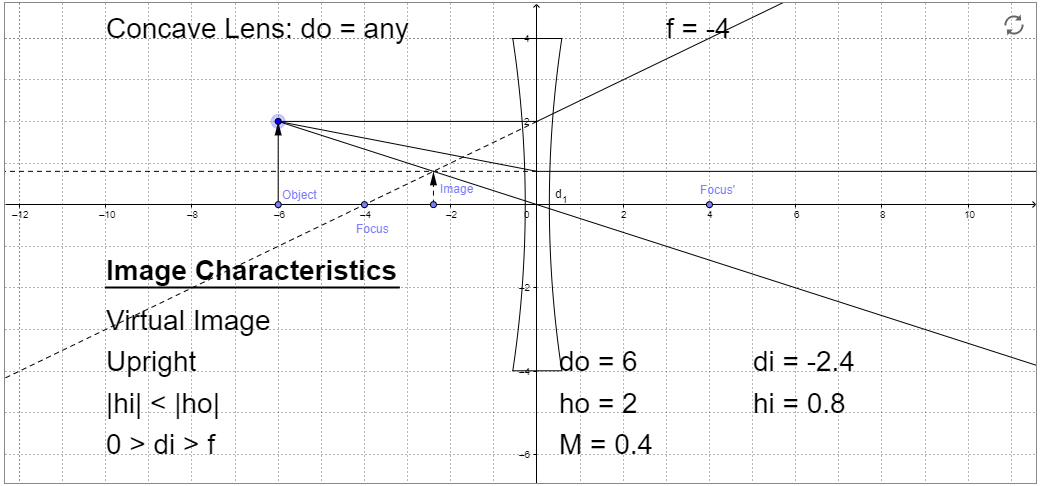
Virtual = image distance is negative.

Magnification equation: M = hi/ho = -di/do 🡪 hi/2 = -2.4/6 🡪 hi = 2\*2.4/6

Hi (image Height) = .8 cm

Upright = height will be Positive

1. In oPhysics (the simulation): Position the focus and object on the simulation to match the initial conditions in the previous question. Confirm that your answers were correct. If not, check your calculations. Reproduce the diagram.



**PART II: Optics of the Eye**

**Background:**

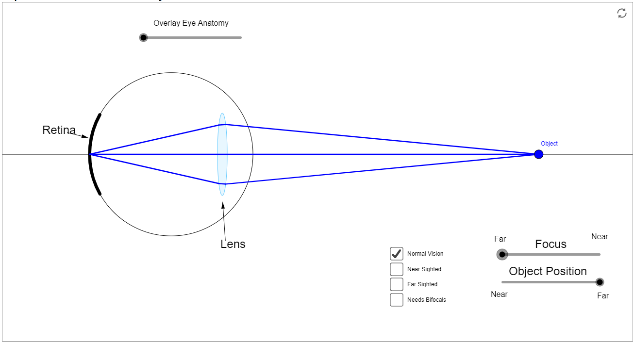
Read the introduction on page 97-100 of the lab manual. Ignore the last section titled “The Human Eye Model.”

You can also view this introductory video

<https://youtu.be/PuCQd5_WUR4>

Link to simulation: <http://ophysics.com/l16.html>

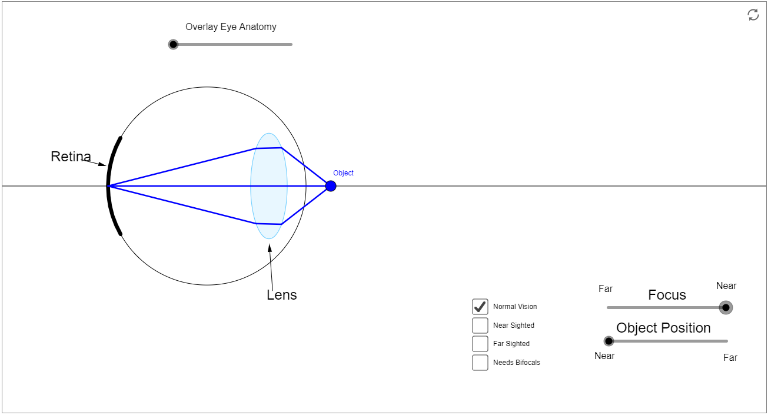
1. Place the slider for “Overlay Eye Anatomy” at the midway point.
2. Read the description below the simulation but take no action yet.
3. Note, “When the refracted rays in the eye come together on the retina, the image is in focus.”
4. Slide the “Focus” of the eye to a point where the image is focused on the retina. Record here the position of the “Focus” and the “Object Position” sliders when the image is focused.



1. What did the lens in the eye do when this adjustment was made? (did the focal length of the lens become shorter or longer?) Why?

The lens flattened and the focal point got pushed to the back of the eyeball. The focal point of the lens became longer.

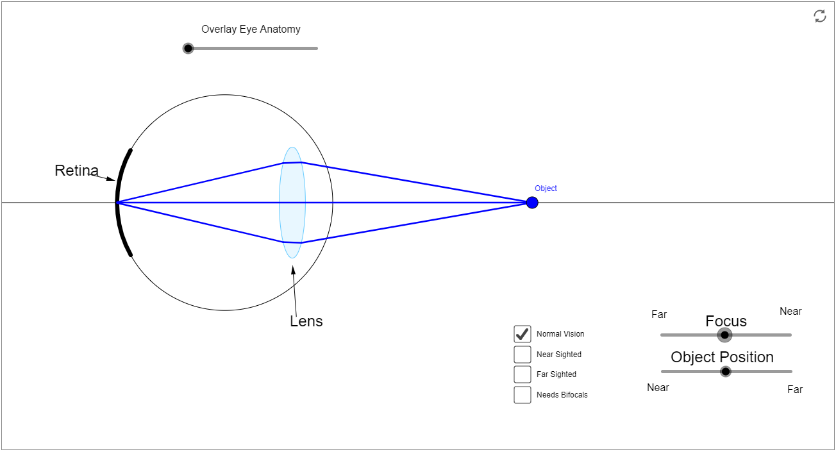
1. Now move the slider for the “Object Position” to the near point. You should see that the image is no longer focused on the retina. Move the slider for “Focus” to a place where the image is again focused on the retina. What is the response of the lens in the eye? Does the focal length of the lens in the eye get shorter, or longer? Why?



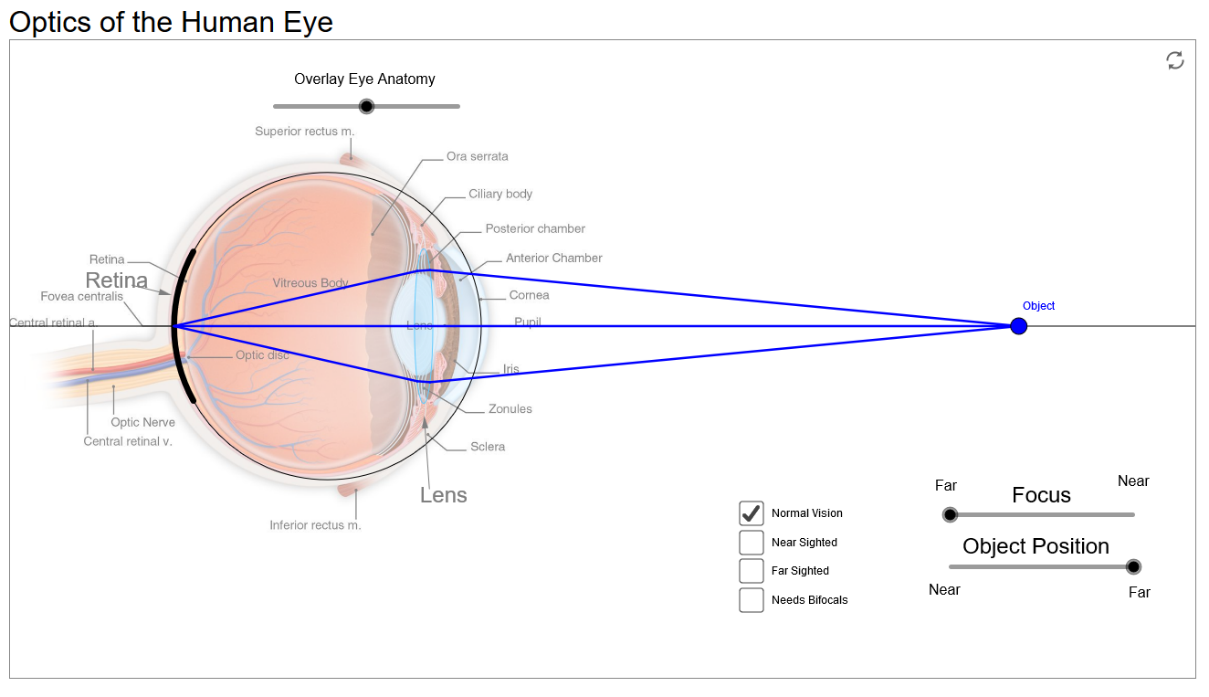
The lens became more convex or rounded and that brought the focal point closer to the lens and object. It gets shorter because it has a tighter angle of reflection.

1. Now set the object position halfway between “near” and “far” … adjust the focus of the eye lens so the image is focused on the retina. How did the focal length of the eye lens change? Why?

It flattened out the lens and pushed the focal point back.



1. The sequence you just finished replicates the normal performance of the eye known as **accommodation**. When the lens won’t focus properly, a person can be “nearsighted” or “farsighted.” To simulate these conditions, do the following.
2. Near and Far sightedness:
   1. With the checkbox for “Normal Vision” checked, adjust both the “Focus” and the “Object Position” to the “Far” setting. You should see this:



* 1. Now click the box marked “Near Sighted”
  2. Does the focal length of the eye lens get shorter, or longer? Why?

It gets shorter due to the lens flattening and moving the focal length forward towards the lens.

* 1. Now click the check box in the upper right corner of the simulation “Correct Nearsightedness.” Explain how the addition of an external lens corrects for nearsightedness.

The new concave lens spreads the light rays apart, which puts them at the correct angle for the lens in the eye to be able to move the focus point at the retina.

* 1. Now, click the checkbox for “Far Sighted” at the bottom center of the simulation. Is the image focused now? (the sliders for “Focus” and “Object position” should be at the “far” positions)

Yes, the image is now in focus because the lens changed shape and moved the focal point back.

* 1. Slide both “Focus” and “Object Position” sliders to the “Near” position. Is the image focused now? Explain. Is the focal point in front of, behind, or on the retina? Why?

No, the lens became wider and more convex. This pushed the focal point behind the retina and now the image is out of focus.

* 1. Now click the check box for “Correct Farsightedness” in the upper right corner. Explain how the addition of an external lens corrects for farsightedness.

This added a thin convex lens that narrowed the rays being sent into the lens and adjusted the angle to bring the focal point forward and put the focus in the retina.

1. Now put both “Focus” and “Object Position” sliders to the “Far” position.
2. Click the “Needs Bifocals” checkbox. How did the focal point of the eye lens change? This simulates a condition known as presbyopia. (<https://en.wikipedia.org/wiki/Presbyopia>)

It widened the lens and made it more rounded. This moved the focal point forward towards the lens and brought it out of focus.

* 1. Slide the “Focus” adjustment … can you ever achieve a point where the image is in focus?

No

* 1. Click the checkbox “Correct Nearsightedness” in the upper right corner. Explain how the new external lens corrects vision.

That added a concave lens which spread the rays out towards the outer edges of the lens and moved the focal point towards the back of the eye and brough it into focus at the retina.

1. Write a summary of what you have learned (at least one paragraph).

I learned that for something to be in focus, the rays need to be directed through the lens at the correct angle to converge at the back of the eye, the retina. You can change where the focal point is inside the eye by placing different shaped lenses in front of the eye to correct any imperfections in the lens size or shape.

1. Do Procedure Part 5: Blind Spot on page 105 of your paper lab manual. Record your observations.

On my right eye, nothing happens I can see the black dot the whole time. On my left eye the black dot does disappear around a foot distance. That is very interesting and odd.

**Post-Lab Feedback:** Record the amount of time it took you to complete this lab activity and describe whether any of the technology or instructions were unclear. What do you think we can do to make this activity better?

Why is the hi in SI boxes, that was a poor decision. It is a 1:1 ratio. Just use cm.

The lab took about 4 hours.