

## Exploration of Optics: Converging and Diverging Lenses

**Lesson Plan for Grades 9-12**

**Length of Lesson: 1 hr 30 min**

**Authored by:** Mohammad Kamyab Javanmardi for UT Environmental Science Institute

**Date created:** 02/05/2015

**Subject area/course:** Physics (optics and lenses)

**Materials:** *(for groups of 2-3 students)*

- sticky notes
- human eye diagram (see resources section)
- light-box or flashlight
- index cards or poster-board (for image cutout)
- meter sticks
- 1 clean convex lens
- 1 clean concave lens
- black poster-board (for image screen)
- 1 worksheet per student
- scissors, markers, tape, clamps, etc..
- Students may want to use various object around the classroom to help stabilize the upright position of the screen, lens, and image source

**TEKS/SEs**

- §112.39. Physics, Grade 9<sup>th</sup>-12<sup>th</sup> (1A, 3F, 7D, 7E)

**Lesson objective(s):** Students will be able to...

- Demonstrate safe practices during laboratory and field investigations.
- Express and interpret relationships symbolically in accordance with accepted theories to make predictions and solve problems mathematically, including problems requiring proportional reasoning and graphical vector addition.
- Investigate behaviors of waves through refraction experiments.
- Describe and predict image formation as a consequence of refraction through thin convex and concave lenses.

## Exploration of Optics: Converging and Diverging Lenses

### Differentiation strategies to meet diverse learner needs:

- Instructor may wish to either use the same lens specifications (focal length) for each lens that the groups use or varying specifications. By using the same lens throughout the class, data and calculations can be more easily compared. For classes that are more comfortable with the concepts and mathematics, different lenses can be used to create a basis for comparison and contrast.
- Instructor can decide to include a double lens experiment in the exploration and elaboration section of the lesson. This should only be done for classes that are more comfortable or already familiar with most of the concepts of refraction and ray diagrams.
- Special needs students such as savants or prodigies can be accommodated by assigning a separate projection on the lens system found within laser pointers. This will offer the necessary challenge that these students may need to better engage with the lesson's content. Other special needs or disabled students can be accommodated with more 1 on 1 instruction time or supplemental videos (see resources section).

### ENGAGEMENT

- Teacher starts the lesson by asking the class if they can identify the key component of a telescope that allows an individual to see distant objects at a greater size than with the naked eye. - the lenses
- Teacher will lead a discussion by asking the class to list and identify objects/devices that utilize lenses for different functions. - microscopes, reading glasses, flashlights, magnifying glasses, etc.
- Teacher will lead a discussion by asking the class to describe what a lens is, what it looks like, and how it's different than a mirror. - transparent medium, sometimes has curved surfaces, lenses allow light to pass through while mirrors reflect light back
- Teacher will explain that not all lenses are the same as they each can be utilized to serve different purposes. There are key components to a lens, and determining those characteristics can allow a manufacturer to design an optimally efficient product for a particular use or activity.
- "This first lab will act to help everyone explore the nature of lenses. However, I must first mention that there are two major types of lenses. There are convex and concave lenses; you will be exploring both."

### EXPLORATION

- Students will create groups of 2-3. Each group will be given a convex and concave lens (if lenses are not all the same, make sure that lenses are labeled).
- Using the other materials provided at the table, each group is to first create a well-defined and resolved image using the light-box or flashlight.
- Next, students will utilize one lens at a time and a screen to find the distance (between screen and lens) where the image is the same size as that of the original source. Students will then measure the distances and image/object heights and record them on their worksheets.
- Students will also note the orientation of the object and image. What happens as the screen is brought closer to lens? What about further away?
- Perform the previous steps for your second lens.

### Exploration of Optics: Converging and Diverging Lenses

#### EXPLANATION

- Instructor will gather all students away from the lab in order to start discussion.
- Teacher will initiate discussion to allow students to share their findings and observations. In the meantime, the teacher will record these observations on the chalkboard or overhead projector.
- Teacher will define terminology for: lens, concave lens, convex lens, object, image, focal length, virtual image, real image (see references section for explanations). As the teacher defines these terms, students will write the definitions under the appropriate section on their worksheets.
- Teacher will allow students 2-3 minutes to discuss with their groups and determine which terms describe the various components of their experimental setup
- Teacher will lead a brief discussion so that an agreed upon diagram of the experiment can be devised
- With these new terms explained, the teacher will demonstrate the basic rules underlying ray diagrams for both convex and concave lenses. Students will be asked to follow along on their worksheets.

#### ELABORATION

- Students will return to their original groups to conduct the elaboration portion of their experiments.
- Students will recreate both set ups, one at a time, from the exploration lab. This time, the groups are to use sticky notes to label each of the components of the set up (object, image, lens, focal length, screen, etc...). Once the set-up is complete, the instructor will verify its accuracy and allow the group to proceed to the next lens setup.
- Upon accurately completing both lens setups (with instructor verification), the group will move on to the eye lens activity.
- Utilizing their understanding of single lens system and the diagram of the human eye (cross section), students will create a lens setup to represent that of the human eye. Key to success of this setup is to first identify what type of lens is required.
- Students will sketch and label a diagram of their setup

#### EVALUATION

- As students write down their last details for their human eye diagram, the teacher will refocus the class and relocate the groups back to their seats.
- Teacher will ask students how they felt the second time creating the lens setups as opposed to the first time.
- Teacher will lead a brief discussion regarding the lens setup that students devised to represent the human eye. What kind of lens does the human eye use? What kind of image is formed on the screen of the eye (retina)? Is it a real or virtual image? Is it upright or inverted?
- Students will answer the following questions to act as their "Exit Quiz" (teacher can display these questions on the board and ask students to answer on a blank sheet of paper)
  1. Explain the difference between a real and virtual image.
  2. Explain some of the fundamental differences between concave and convex lenses.
  3. Define focal length (you can use diagrams to help support your explanation).
  4. What kind of lens does the human eye use?
  5. Is the image on the human retina (screen) upright or inverted? If inverted, why do you think we don't see an inverted image (purely a prediction)?



## Exploration of Optics: Converging and Diverging Lenses

### SOURCES AND RESOURCES

- Dr. Bruce Hood's Hot Science – Cool Talks Lecture #95
- Refraction and Diffraction - <http://csep10.phys.utk.edu/astr162/lect/light/ref-diff.html>
- Ray Diagrams for Lenses - <http://hyperphysics.phy-astr.gsu.edu/hbase/geoopt/raydiag.html>
- Converging (convex) Lens Ray Diagram: How To - <http://www.physicsclassroom.com/class/refrn/Lesson-5/Converging-Lenses-Ray-Diagrams>
- Diverging (concave) Lens Ray Diagram: How To - <http://www.physicsclassroom.com/class/refrn/Lesson-5/Diverging-Lenses-Ray-Diagrams>
- How Laser Pointers Are Made (special accommodations material) - <http://www.madehow.com/Volume-7/Laser-Pointer.html>
- Optics Terms and Definitions - <http://osa.magnet.fsu.edu/terms/general.html>
- Human Eye Cross Section - [http://www.optique-ingenieur.org/en/courses/OPI\\_ang\\_M07\\_C02/co/Contenu.html](http://www.optique-ingenieur.org/en/courses/OPI_ang_M07_C02/co/Contenu.html)

## Exploration of Optics: Converging and Diverging Lenses

### EXPLORATION ACTIVITY or ACTIVITIES

**Purpose:** These activities are designed to provide students hands on experience with concave and convex lenses. By first teaching all of the terminology and the laws of refraction, students are deprived the explorative nature of the experiments. For this reason, students are allowed to collaborate in small groups to first experiment with basic lens setups. Students will then be formally taught lens diagram terminology as well as the ray diagram laws of refraction. With this formal knowledge, students will recreate both the convex and concave lens setups followed up by a separate lens setup to represent the anatomy/physiology of the human eye.

### Materials: (for groups of 2-3 students)

- sticky notes
- human eye diagram (see resources section)
- light-box or flashlight
- index cards or poster-board (for image cutout)
- meter sticks
- 1 clean convex lens
- 1 clean concave lens
- black poster-board (for image screen)
- 1 worksheet per student
- scissors, markers, tape, clamps, etc..
- Students may want to use various object around the classroom to help stabilize the upright position of the screen, lens, and image source

**Safety Information:** This lab involves several hazards that instructors should be aware of. As there are various light sources being used during both experiments, students and instructors should be aware of potential burn and fire hazards associated with incandescent bulbs. Students should also refrain from pointing the light source in the direction of anyone's eyes as permanent or semi-permanent damage could be done to the eye's photoreceptors. Students should also follow the lab's standard safety protocols.

### Procedure:

#### Exploration:

- Students will create groups of 2-3. Each group will be given a convex and concave lens (if lenses are not all the same, make sure that lenses are labeled).
- Using the other materials provided at the table, each group is to first create a well-defined and resolved image using the light-box or flashlight.
- Next, students will utilize one lens at a time and a screen to find the distance (between screen and lens) where the image is the same size as that of the original source. Students will then measure the distances and

### **Exploration of Optics: Converging and Diverging Lenses**

image/object heights and record them on their worksheets.

- Students will also note the orientation of the object and image. What happens as the screen is brought closer to lens? What about further away? Perform the previous steps for your second lens.

#### **Elaboration:**

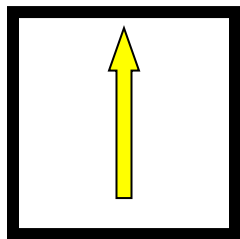
- Students will return to their original groups to conduct the elaboration portion of their experiments.
- Students will recreate both set ups, one at a time, from the exploration lab. This time, the groups are to use sticky notes to label each of the components of the set up (object, image, lens, focal length, screen, etc...). Once the set-up is complete, the instructor will verify its accuracy and allow the group to proceed to the next lens setup.
- Upon accurately completing both lens setups (with instructor verification), the group will move on to the eye lens activity.
- Utilizing their understanding of single lens system and the diagram of the human eye (cross section), students will create a lens setup to represent that of the human eye. Key to success of this setup is to first identify what type of lens is required.
- Students will sketch and label a diagram of their setup

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**TEACHER PAGE(S)**

**Exploration:**

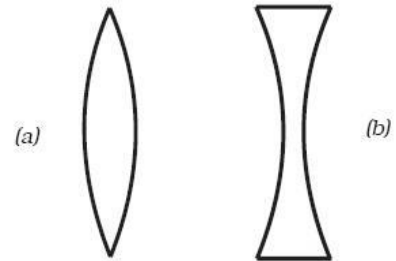
- Create a group of 2-3 students. Pick or go to your group’s assigned lab station (DO NOT TOUCH MATERIALS UNTIL INSTRUCTED).
- You will notice that there are 2 different lenses at your station. One is wider in the middle and tapers at the ends while the other is thin in the middle and widens at the ends. You will pick one of these to work with at a time.
- You will also notice that you have a light source. Attach your cutout image to the front of the light source so that a resolvable and clear image can be seen. – **Teacher should have these images cut out and measured (height) beforehand. An image of an arrow is great option for this type of activity.**



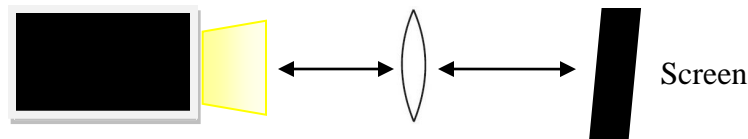
Front View (this shows the cutout arrow placed on the front of the light source)



Side View



- Use your material and potentially other materials around the room in order to create a lens light source setup that generates an image the same height and size as that of the original source. The basic diagram is depicted below (side view).



Light Source (with cutout mounted in front)

Lens

Screen


Lens 1: Original image height on light source: \_\_\_\_ cm  
 Final image height on screen: \_\_\_\_ cm  
 Distance between light source and lens: \_\_\_\_ cm  
 Distance between lens and screen: \_\_\_\_ cm  
 Orientation of the final image (upright or upside-down): \_\_\_\_\_

Observations and notes:

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Lens 2: 

Original image height on light source: \_\_\_\_ cm

Were you able to see a final image? \_\_\_\_\_

What are some of your predictions for why this happened?

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Observations and notes:

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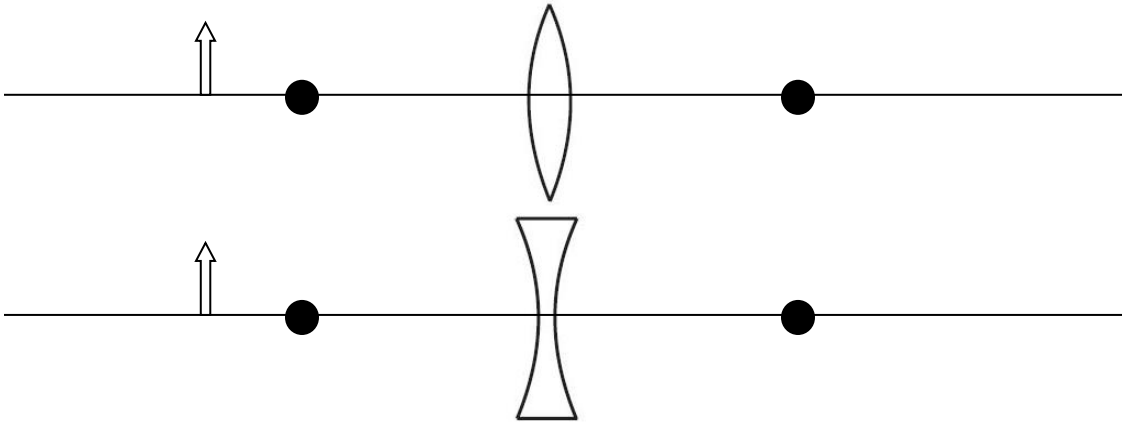
#### **Explanation:**

Terms and Definitions:

- **Lens:** A transparent optical component consisting of one or more pieces of optical glass with surfaces so curved that they serve to converge or diverge the transmitted rays from an object, thus forming a real or virtual image of that object.
- **Concave (Diverging) Lens:** A hollow curved surface; curved inward | the bending of rays away from each other.
- **Convex (Converging) Lens:** Spherically shaped; curves outward | the bending of light rays toward each other.
- **Object:** The figure seen through or imaged by an optical system.
- **Image:** The reproduction of an object produced by light rays. If the beam converges to a point, a real image is formed. If the beam diverges, a virtual image is formed.
- **Focal Length:** The distance from a lens or mirror to its focal point.
- **Focal Point:** The point on the optical axis of a lens, to which an incident bundle of parallel rays will converge.
- **Virtual Image:** an optical image formed from the apparent divergence of light rays from a point, as opposed to an image formed from their actual divergence.
- **Real Image:** A type of image created by converging light rays. This type of image would form on the image side of a lens, where it could be projected. The opposite of a real image is a virtual image.



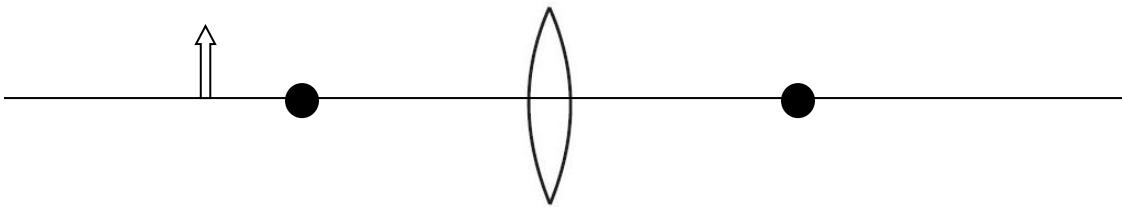
**Exploration of Optics: Converging and Diverging Lenses**



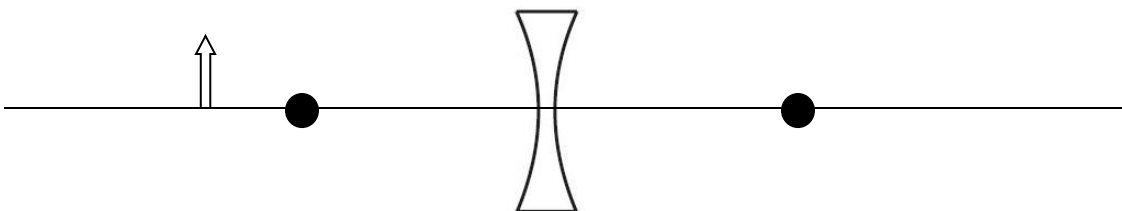
Complete these two ray diagrams along with the instructor.

**Elaboration:**

- You will return to your original groups for the elaboration portion of the lesson
- First, create the convex lens setup. When finished, ask your instructor to verify the accuracy of the setup. After being approved, sketch and label a ray diagram of your setup.

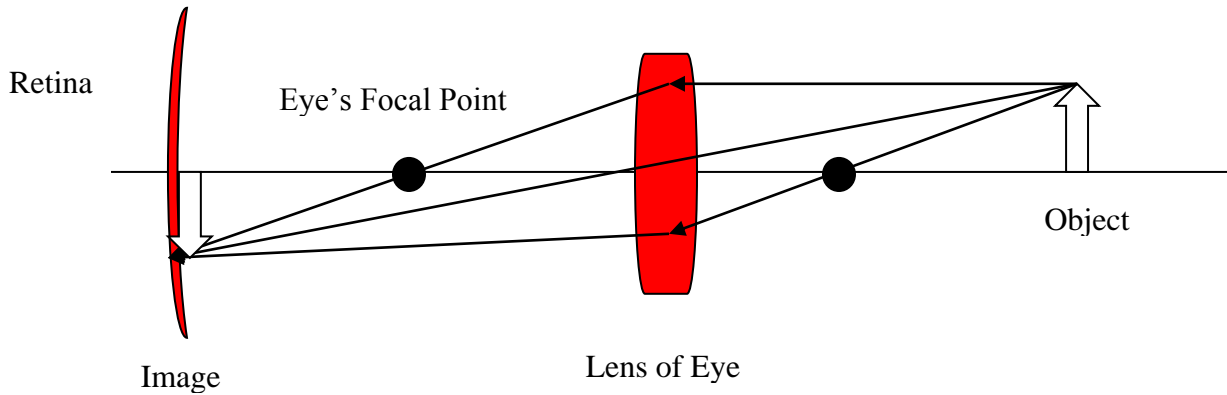


- Next, create the concave lens setup. When finished, ask your instructor to verify the accuracy of the setup. After being approved, sketch and label a ray diagram of your setup.



- Locate the image of the cross section of a human eye. Use the image and your knowledge about lenses to create setup for the human eye by using the same materials (HINT: Retina is like a screen in the back of the eye). Sketch your diagram and properly label each component both in terms of eye anatomy and optics terminology.

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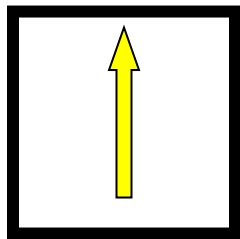
What type of lens did you use for the eye diagram? Convex (convergent)

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**STUDENT PAGE(S)**

**Exploration:**

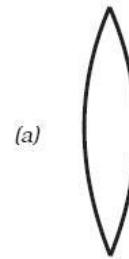
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Front View (this shows the cutout arrow placed on the front of the light source)



Side View

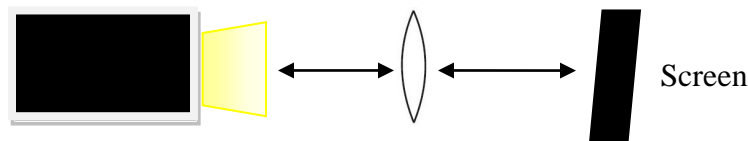


(a)



(b)

- Use your material and potentially other materials around the room in order to create a lens light source setup that generates an image the same height and size as that of the original source. The basic diagram is depicted below (side view).



Light Source (with cutout mounted in front)

Lens

Screen

Lens 1: 
  
 Original image height on light source: \_\_\_\_ cm
   
 Final image height on screen: \_\_\_\_ cm
   
 Distance between light source and lens: \_\_\_\_ cm
   
 Distance between lens and screen: \_\_\_\_ cm
   
 Orientation of the final image (upright or upside-down): \_\_\_\_\_


Observations and notes:

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Lens 2: 

Original image height on light source: \_\_\_\_ cm

Were you able to see a final image? \_\_\_\_\_

What are some of your predictions for why this happened?

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Observations and notes:

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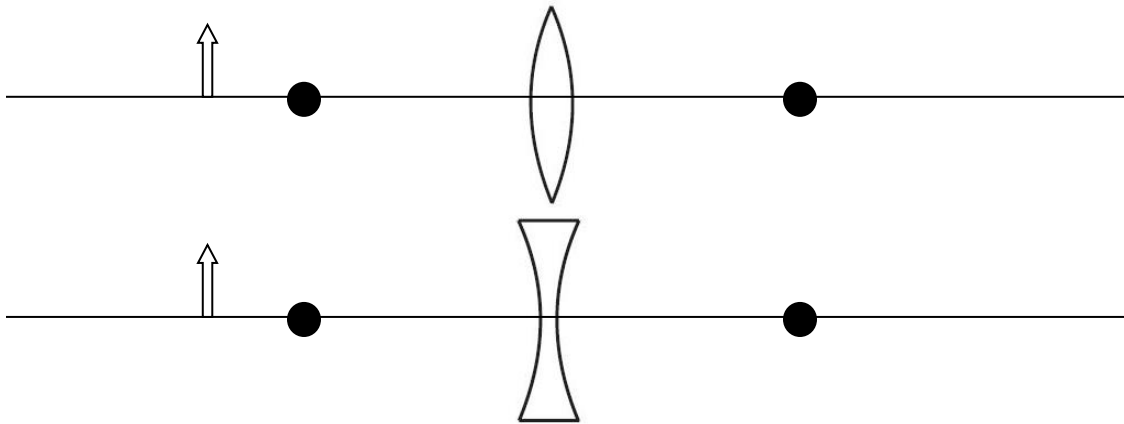
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### Explanation:

Terms and Definitions:

- **Lens:**
  
- **Concave (Diverging) Lens:**
  
- **Convex (Converging) Lens:**
  
- **Object:**
  
- **Image:**
  
- **Focal Length:**
  
- **Focal Point:**
  
- **Virtual Image:**
  
- **Real Image:**

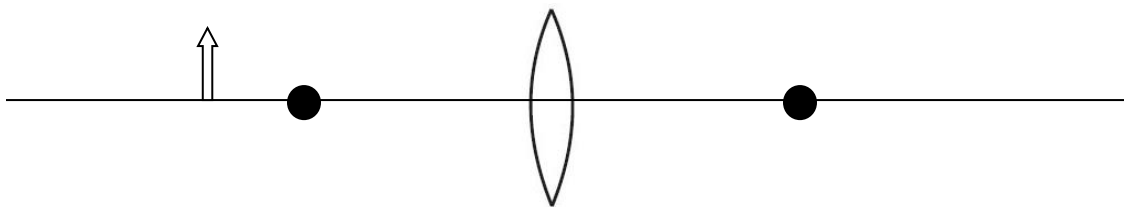
**Exploration of Optics: Converging and Diverging Lenses**



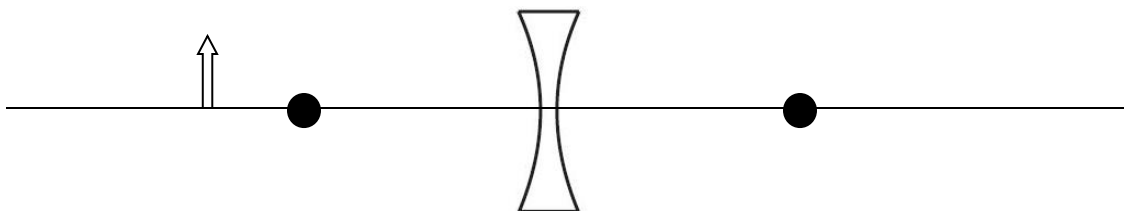
Complete these two ray diagrams along with the instructor.

**Elaboration:**

- You will return to your original groups for the elaboration portion of the lesson
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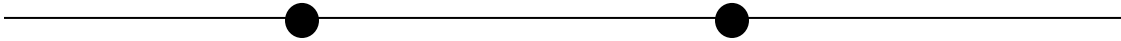


- Next, create the concave lens setup. When finished, ask your instructor to verify the accuracy of the setup. After being approved, sketch and label a ray diagram of your setup.



- Locate the image of the cross section of a human eye. Use the image and your knowledge about lenses to create setup for the human eye by using the same materials (HINT: Retina is like a screen in the back of the eye). Sketch your diagram and properly label each component both in terms of eye anatomy and optics terminology.

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What type of lens did you use for the eye diagram? \_\_\_\_\_