Lab Handout

Lab 22. Design Challenge

How Should Eyeglasses Be Shaped to Correct for Nearsightedness and Farsightedness?

Introduction

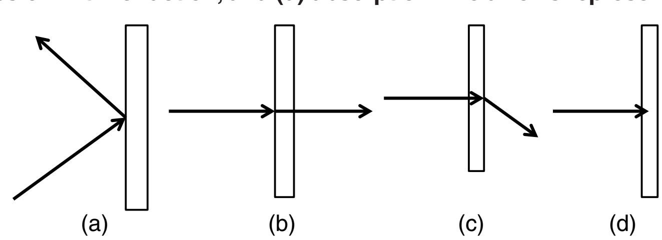
The study of light, an area in physics known as optics, dates back to the times of the ancient Mesopotamians, Egyptians, Greeks, and Romans. It is believed that the first lenses were made as early as 750 B.C. (see the Nimrud lens at *www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=369215&partId=1&searchText=lens&page=1*). Early lenses were used to manipulate light and likely most often used to start fires by focusing light in a small area to generate enough heat to ignite flammable material. Over time, scientists have used their understanding of the properties of light to develop many useful instruments for their investigations and for society, including telescopes, microscopes, magnifying glasses, and eyeglasses. Each of these instruments uses at least one lens to change the path of light rays to be more beneficial to the person using the instrument.

Light rays behave in predictable ways. There are three general ways that light rays can behave when they interact with, or pass through, a lens: they can be reflected, transmitted, or absorbed. When light rays are reflected, that means they come into contact with a surface and bounce back in the direction they came from; this is called reflection. When light rays come into contact with a surface and continue on, passing through the surface, it is called transmission. The third behavior for light rays is that when they hit a surface they may not be reflected or transmitted but instead are absorbed. In many cases when light rays hit a surface, a combination of these behaviors happens. For example, some rays may get reflected while others are transmitted. Also, when light rays are reflected or transmitted, it is common for them to change direction. When light rays are transmitted through a substance but change direction on the other side, it is called refraction. Figure L22.1 shows examples of what happens when light rays are reflected, transmitted, or absorbed.

When light rays are transmitted through an object, such as a lens, the light is refracted in specific ways based on the shape of the object. Scientists have conducted many investigations to understand how light rays behave when they pass through a lens. Two major

FIGURE L22.1

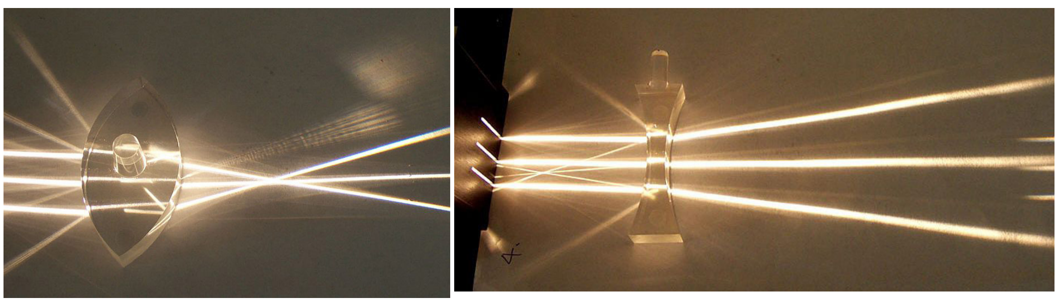
Examples of how light behaves when it interacts with a medium: (a) reflection, (b) transmission, (c) transmission with refraction, and (d) absorption. The arrows represent light rays.



findings from these investigations are as follows: When light rays are transmitted through a convex lens, the light rays come together, or converge on the other side; when light rays are transmitted through a concave lens, the light rays spread out, or diverge, on the other side. Figure L22.2 shows how light rays behave when they pass through a convex or concave lens. Glass lenses used in instruments like the ones described earlier in this section are very common, and even our own eyes have lenses that collects light rays to help us see.

FIGURE L22.2

A convex (a) and a concave (b) lens refracting light



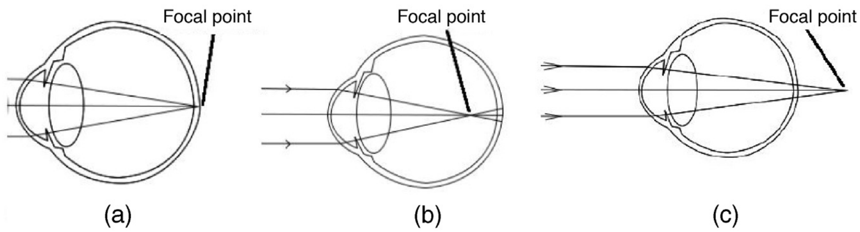
(a) (b)

The lens in a human eye focuses the incoming light rays on the retina, which is the back portion of the eyeball. However, there are times when a person's eye does not focus the light correctly, resulting in the person being nearsighted or farsighted. When a person is nearsighted, the lenses in the eyes focus the incoming light rays before they have a chance to reach the retina. When a person is farsighted, the lenses in the eyes do not focus the incoming light rays fast enough and they are still spread out when the light rays reach the retina.

Eyeglasses or contact lenses are used to correct the vision of people with nearsightedness or farsightedness. It is believed that eyeglasses were first invented in the 1200s and then gained popularity in the mid-1400s with the invention of the printing press and the rise in the number of people that had access to books and began learning to read (see "Timeline of Eyeglasses" at *www.museumofvision.org/exhibitions/?key=44&subkey=4&relkey=35*). The lenses of the eyeglasses (or modern contact lenses) work together with the lenses of the eye to change the path of the incoming light rays to ensure that they focus on the retina, resulting in clear vision. Figure L22.3 (p. 212) shows examples of eyes and incoming light rays that represent normal vision, nearsightedness, and farsightedness.

FIGURE L22.3

Eyeball models for (a) normal vision, (b) nearsightedness, and (c) farsightedness



Your Task

Use what you know about the behavior of light and the relationship between the structure and function of a lens to develop a model that helps you explain how different shapes of eyeglasses will correct the vision of someone who is nearsighted and someone who is farsighted. Your model should demonstrate the two types of vision conditions as well as show how your solution corrects each of the vision conditions.

The guiding question of this investigation is, **How should eyeglasses be shaped to correct for nearsightedness and farsightedness?**

Materials

You may use any of the following materials during you investigation:

Consumable	Equipment
Large paper	• Light box with power supply • Lens kit • Protractor • Ruler • Safety glasses or goggles

Safety Precautions

Follow all normal lab safety rules. In addition, take the following safety precautions:

1. Wear sanitized safety glasses or goggles during lab setup, hands-on activity, and takedown.
2. Use caution when working with the light source. It can get hot and burn skin.
3. Do not look directly at the light coming from the light box.
4. Use only GFCI-protected electrical receptacles for the light box power supply.
5. Use caution when handling glass. It can have sharp edges, which can cut skin.

6. Lightbulbs are made of glass. Be careful handling them. If they break, clean them up immediately and place in a broken glass box.
7. Wash hands with soap and water after completing the lab activity.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

The first step in developing your vision models is to use lenses from your kit to determine how to draw a model eyeball that represents normal vision. Then, draw a model eyeball that represents nearsightedness and a model eyeball that represents farsightedness. Remember that each model eyeball needs a lens that remains part of the model eyeball (this lens represents the lens portion of the human eye, and removing it would be the same as doing surgery on your model eyeball), and that lens cannot be used to represent the eyeglasses intended to correct the vision in that model. Work with each model separately; this allows you to use a lens from your kit more than once if necessary.

To determine *what type of data you need to collect,* think about the following questions:

- What information do you need to make your models?
- What measurements will you take during your investigation?
- How will you know if the vision has been corrected in your models?

To determine *how you will collect your data,* think about the following questions:

- What equipment will you need to collect the data you need?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of the data you collect?
- How will you organize your data?

To determine *how you will analyze your data,* think about the following questions:

- How can you show that the vision or light rays in your model have changed?
- What type of diagrams or images could you create to help make sense of your data?

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

- how scientists use models to understand complex systems;

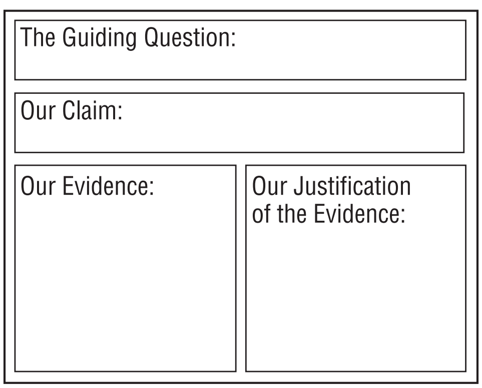
- how the structure and function of an object are related;
- science as a culture and how it influences the work of scientists; and
- how scientists must use imagination and creativity when developing models and explanations.

Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a *claim*, *evidence* to support your claim, and a *justification* of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L22.4.

FIGURE L22.4

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- How did you collect your data? Why did you use that method? Why did you collect those data?
- What did you do to make sure the data you collected are reliable? What did you do to decrease measurement error?
- How did you group analyze the data? Why did you decide to do it that way? Did you check your calculations?

- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that way?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most acceptable and valid answer to the research question!

Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections. Each section should provide an answer to the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable and valid!