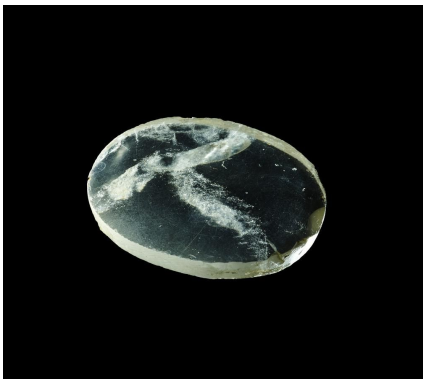
Design Challenge: How Should Eyeglasses Be Shaped to Correct for Nearsightedness and Farsightedness?

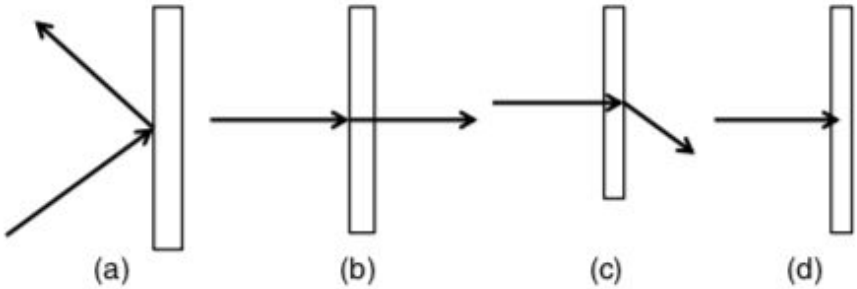
Introduction

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 figure to the right). 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.



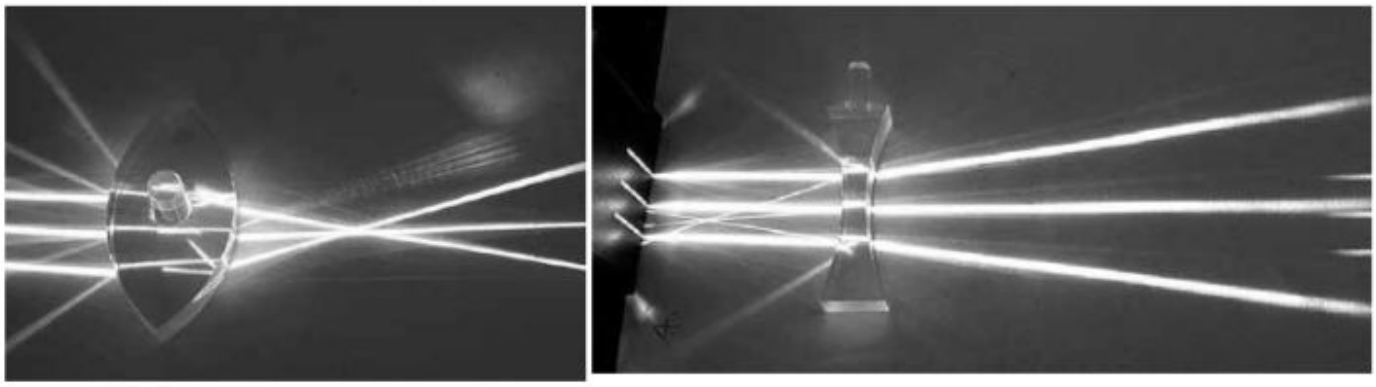
Light rays behave in predictable ways. There are three general ways that light rays can behave when they interact with, or pass through, a lens: they can be reflected, transmitted, or absorbed. When light rays are reflected, that means they come into contact with a surface and bounce back in the direction 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. The figure below shows examples of what happens when light rays are reflected, transmitted, or absorbed.

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.



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 inves- tigations to understand how light rays behave when they pass through a lens. Two major 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. The figure on the next page 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 collect light rays to help us see.

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

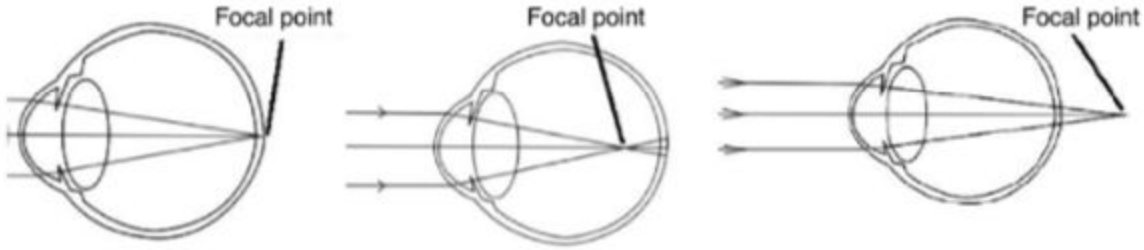


(a) (b)

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. 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. The figure below shows examples of eyes and incoming light rays that represent normal vision, nearsightedness, and farsightedness.

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



(a) (b) (c)

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 will use an online simulation called *How Are Lenses Used to Correct Vision?* to conduct your investigation. You can access the simulation by going to the following website:
http://www.glencoe.com/sites/common_assets/science/virtual_labs/E11/E11.html

Getting Started
The first step in developing your vision models is to read the information in the sidebar of the online lab, then go through the procedure described on that page to complete your investigation.

Here is an example data table you could use:

Patient Vision Log

Patient	Vision Diagnosis	Corrective Lens Type	Lens Strength
1			
2			
3			
4			
5			
6			

Once you've completed your investigation, you will need to use the data you collected to answer the guiding question and complete your conclusion.

Report
Once you have completed your research, you will need to prepare an investigation report that consists of four sections (be sure to have section headings):

1. Introduction: Give some background information on the topic. Explain what question you were trying to answer and include a hypothesis. (Background info, research question and hypothesis)
2. Procedure: What did you do during your investigation and why did you conduct your investigation in this way? (How you collected and analyzed data)
3. Data: Include a data table and/or graph to show your results. Be sure to include a title for your table or graph with labels for the variables.
4. Conclusion: What is your argument? (Claim - Evidence - Reasoning)

Your report should answer these questions in two pages or less. The report must be typed, and any diagrams, figures, or tables should be embedded into the document. Type your report on Google Docs (12 point font, double-spaced) and share it with your teacher. Your report will be graded based on the rubric in the class syllabus.