Name _____ Date _____ Period _____

Lab: Properties of Light

CHAPTER 27: LIGHT WAVES

Introduction: The only thing we can really see is light. But what is light? During the day the primary source of light is the sun, and the secondary source is the brightness of the sky. Other common sources are flames, white-hot filaments in lamps, and glowing gases in glass tubes. Almost everything we see, such as this page, is made visible by the light it reflects from such sources. Some materials, such as air, water, or window glass, allow light to pass through. Other materials, such as thin paper or frosted glass, allow the passage of light in diffused directions so that we can't see objects through them. Most materials do not allow the passage of any light, except through a very thin layer.

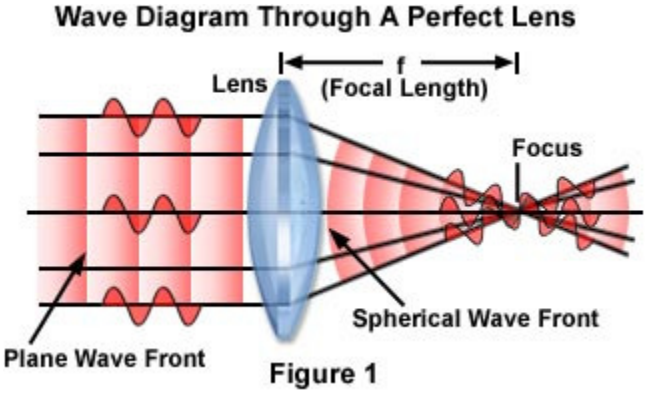


Figure 1

Ponds or swimming pools appear shallower than they actually are. A pencil in a glass of water appears bent, the above a hot stove seems to shimmer, and the stars twinkle. These effects are due to the **refraction** of light. Changes in the speed of light as it passes from one medium to another, or variations in the temperatures and densities of the same medium, cause refraction. The directions of the light rays change because of refraction. A lens is a piece of transparent material, such as glass, that refracts light. A lens forms an image by bending rays of light that pass through it.

In the following activities, you will observe some of these very special properties of light as you make a simple pinhole magnifier, a water drop lens, a camera obscura, and a pair of Inuit snow goggles.

Part 1: Making a Pinhole Magnifier

Who needs expensive optical equipment? A pinhole in an index card can act like a magnifying glass, helping your eye focus on an object that is very close to you. However, by limiting the amount of light that reaches your eye from the object, the pinhole also makes the object appear dimmer.

Materials:

- 3 x 5 card
- Straight pin or needle
- Aluminum foil
- A lamp (10 to 25 watt) light bulb
- Making tape
- X-Acto knife

Proceedure:

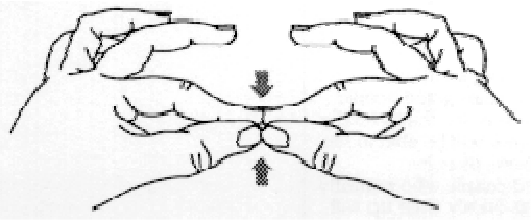
1. Cut a hole about 1 inch (2.5 cm) square in a file card

2. Tape a piece of aluminum foil over the hole in the card and use the pin to punch a hole in the center of the foil. You can make a good pinhole by placing the foil on a thick piece of cardboard and rotating a needle.

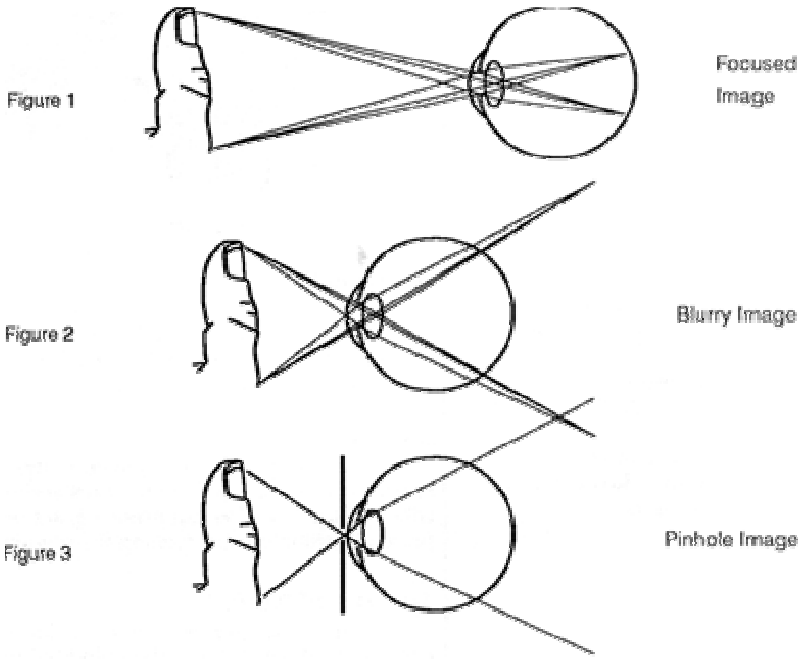
3. Hold the card near your eye and look at several different objects around the classroom. You can, for example, examine a computer screen or a television screen up close using a pinhole magnifier.

4. Try using pins or needles with different diameters to make different-sized holes. Notice that the smaller the pinhole is, the dimmer your view. As the pinhole is made smaller, the image at first becomes sharper, but then is blurred by diffraction.

5. You can even form a pinhole by curling your index finger. Or try this as a magnifier:



The pinhole magnifier works on a very simple principle:
The closer you get to an object, the bigger it looks to you. This is because the closer you are to the object, the larger the image the object forms on your retina (see Figure 1). Unfortunately, however, there is a limit to this. If you get too close to the object, your eye is not able to bend some of the light rays enough to obtain a focused image. As a result, the image becomes blurry or fuzzy (see Figure 2). The pinhole magnifier gets around this problem by limiting the rays that come to you from each part of the object (see Figure 3).

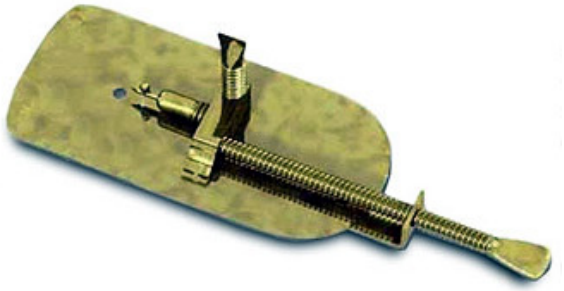


Sadly, there is a trade-off between the resolution, or sharpness, of the image and its brightness. A tiny pinhole produces a very sharp image, but because it cuts down on the number of rays that enter your eye, the pinhole makes the object look much dimmer.

By using a pinhole magnifier, nearsighted people who normally see things fuzzily at a distance will be able to see them clearly; likewise, farsighted people who normally see things fuzzily close up will be able to see them clearly.

From: http://www.exploratorium.edu/snacks/pinhole_magnifier/index.html

Part 2: Constructing a Water Drop Lens



It was Antony Van Leeuwenhoek (1632-1723), a Dutch draper and scientist, and one of the pioneers of microscopy who in the late 17th century became the first man to make and use a real microscope.

He made his own simple microscopes, which had a single lens and were hand-held. Van Leeuwenhoek achieved greater success than his contemporaries by developing ways to make superior lenses, grinding and polishing a small glass ball into a lens with a magnification of 270x, the finest known at that time (other microscopes of the time were lucky to achieve 50x magnification). He used this lens to make the world's first practical microscope.

Leeuwenhoek's microscope used a single convex glass lens attached to a metal holder and was focused using screws. Anthony Leeuwenhoek became more involved in science and with his new improved microscope was able to see things that no man had ever seen before. He saw bacteria, yeast, blood cells and many tiny animals swimming about in a drop of water. People did not realize that magnification might reveal structures that had never been seen before - the idea that all life might be made up of tiny components unseen by the unaided eye was simply not even considered.

You can easily make a model based on Leeuwenhoek's microscope. A very simple one is built from only a paperclip. Follow the directions below to contruct one of your own.

Materials:

- Paper clip
- Needle nose pliers
- Oil
- Water (preferably distilled water)

Proceedure:

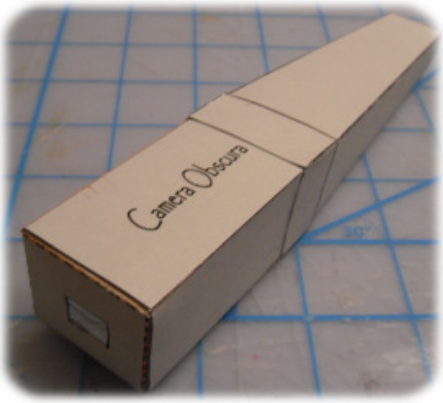
1. Straighten out the paperclip with a pair of pliers (small needle nose pliers work best for this project). Bend a small, complete loop in one end of the clip. The loop should be about 1/16 inch (1.5 mm) across and as round as possible (try not to scratch the metal forming the loop

2. Rub a little oil on the loop to give it a fine coating.

3. Dip it in water (preferably distilled and slowly remove it. A drop of water should form that will act as a lens. It is not nearly as strong as Leeuwenhoek's lenses, but it is the same spherical shape, and will magnify at about 2X or more.

4. Using you Water Drop Lens you have constructed, observe a small object (pollen, small insect, grains of salt or sand, etc.)

Part 3: Making a Camera Obscura:



The **camera obscura** (Latin for "dark room"; "darkened chamber") is an optical device that projects an image of its surroundings on a **screen**. It is used in drawing and for entertainment, and was one of the inventions that led to photography. The device consists of a box or room with a hole in one side. Light from an external scene passes through the hole and strikes a surface inside where it is reproduced, upside-down, but with color and perspective preserved. The image can be projected onto paper, and can then be traced to produce a highly accurate representation.

As a pinhole is made smaller, the image gets sharper, but the projected image becomes dimmer. With too small a pinhole the sharpness again becomes worse due to diffraction. Some practical camera obscuras use a lens rather than a pinhole because it allows a larger aperture, giving a usable brightness while maintaining focus.

Materials:

- Card stock template (cut out)
- Scissors
- Straight pin or needle
- Aluminum foil
- Wax paper
- Scotch tape
- X-Acto knife

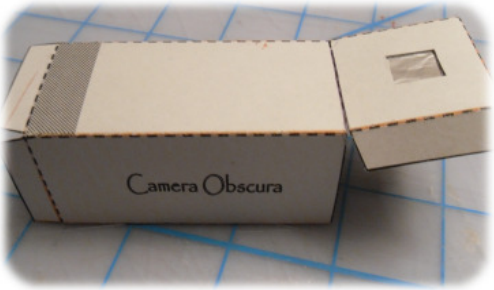
Proceedure:

1. Cut out template parts using scissors along solid lines.

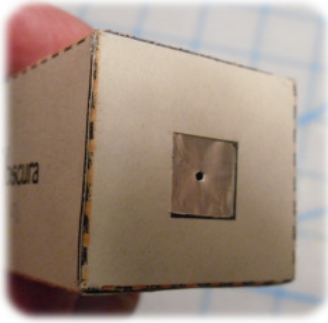
2. Scribe along dashed lines using ballpoint pen (empty pen works best). This will allow you to easily bend and fold parts.

3. Fold PART 1 and glue tab on inside forming a square tube.

4. Cut out small square opening for pinhole lens and glue small piece of aluminum foil on inside of opening.



5. Once it is dried, use a small needle to form pinhole lens in center of aluminum foil.



6. Fold and glue tabs on end opposite pinhole lens (this adds some strength to the tube)

7. Fold tabs on end piece and form bend and glue to inside of square tube.

8. Cut out piece of wax paper and tape it to end of PART 1 opposite the pinhole lens.

9. Fold PART 2 along dashed lines and glue to form tube.

10. Once PART 2 has dried, glue it to PART 1 forming an eyepiece.

11. You are now ready to test your Camera Obscura. Aim your camera at a brightly lighted object and test it out.

Part 4: Making Inuit Snow Goggles

These Inuit snow goggles were collected by Henry Larsen while aboard RCMP ST ROCH, 1929-1948. The intense sunlight of the springtime in the Arctic, when reflected from the snow-covered ground, causes a temporary condition called snow blindness. To prevent this, the Inuit made snow goggles. These were fashioned to fit the contours of the face snugly to allow light to enter only through narrow viewing slits that restricted the field of vision and reduced the amount of light that reached the optic nerve. The area behind each eye

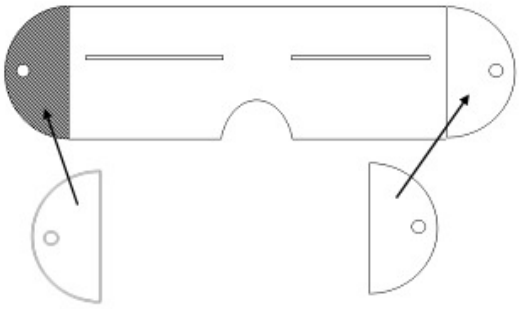
slit was hollowed out to prevent eye contact and blackened to eliminate glare. Earlier (dating back centuries) goggles were made of bone in the wood scarce Arctic, but later, when wood became more plentiful, such as the time these were made in the early twentieth century, wooden goggles began to appear. The width of the slits governs the width of lateral vision, and the narrower the slit, the more the acuity of vision. This simple but ingenious invention is superior to modern high-tech sunglasses.

Materials:

- Card stock template
- X-Acto knife
- Scissors
- Metal straight-edge (ruler)
- Rubber bands or string (for strap)

Proceedure:

1. Cut out PART 1 and PART 2 out of card stock template.
2. Use single hole punch to make holes for rubber band strap in both parts
3. Cut PART 2 into two pieces and glue onto PART 1 for extra strength
4. Cut out slit in PART 1. You don't need a large slit to see and the smaller the slit, the fewer UV rays that can reflect into your eyes.
5. You may want to adjust the cut-out for your nose to fit correctly and have your eyes aligned with the slits.
6. Attach rubber band or string to holes on each end to form strap



7. Try them out! Try looking through goggles with different sized slits cut into them. Observe what happens to the image.

Conclusion Questions:

1. Which activity did you find most interesting……and why?

2. How does a pinhole magnifier work? Discus size of hole and its relationship to the sharpness of image.

3. Why does the light “bend” and magnify an object when it travels through the Water Drop Lens?

4. What is a Camera Obscura?

5. What happened to the image when you looked through your Camera Obscura? Explain

6. What happened to the image in your Camera Obscura when the pinhole was made larger?

7. How does the width of the slit in your Inuit Snow Goggles have on the acuity of vision?

8. How do the Inuit Snow Goggles protect your eyes? (Discus wavelengths of light and intensity)

9. What is diffraction and refraction of light? When does it occur and why?

10. How are sound waves and light waves similar? Different?