

# Light Refraction

## Teacher Lesson Plan

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### Background Information

- Light is energy that travels in waves.
- Light travels in straight paths called rays until it hits an object.
- Refraction means the bending of a wave due to the change in speed as it moves from one medium to another. The frequency does not change.
- The amount of refraction (bending) depends on the density of the material it is entering, the wavelength and angle which the light enters the medium.
- Lenses refract light. They have at least one curved surface. The light rays bend as they pass through it so they change direction. There are two types of lenses.
  - In a convex lens, the surfaces bulge outward in the center. It makes the parallel light rays passing through it bend inward and meet in a spot beyond the lens called the focal point. The distance between the focal point and the lens is the focal distance. By altering the focal distance, you focus the light rays which produce the image. They are used in telescopes and binoculars to bring distant light rays to focus in your eyes. The lens in your eye and glasses are other examples.
  - A concave lens has the outer surfaces curving inward. It makes the parallel light rays spread out. They are used in projectors to make the light rays spread out.

### Student Activities – Light Refraction

#### LESSON 1: Pencil in a Cup

##### Lesson Materials:

- Clear plastic cups
- Identical pencils
- At least 3 different liquids: Mineral oil, water, vegetable oil or corn syrup

##### Procedure:

- On a demonstration table in front of the room, place the cups. Fill each cup half way with each substance. Place a pencil in each cup.
- Have students observe the pencil at the level it enters the liquid.
- Light travels from air to the liquid and it appears that the pencil bends at the point it enters the liquid.
- The degree of the angle that the pencil appears to bend depends on the density of the liquid.

### Student Discussion Questions:

- Why do the pencils look like they are bent or broken? *When the light traveling in air, enters the water (or other liquid), it changes speed. The change in speed makes it appear that the pencil is bent.*
- The pencils in the different liquids appear to bend different degrees. Why? *The densities of the liquids are different so the change in the speed of light varies resulting in different degrees of bending.*

## LESSON 2: Water Drop Magnifier

### Lesson Materials:

- One 2" by 3" piece of cardboard or cardstock
- One-inch square piece of thin clear plastic or plastic wrap
- Pair of scissors
- Tape
- Water
- Medicine dropper



### Procedure:

- Cut a dime-size hole in the middle of the cardboard.
- Set the clear piece of plastic over the hole, and tape it down. Tape it around the edge without covering the hole. Fold each end of the cardboard down  $\frac{1}{4}$  inch.
- Using a medicine dropper, place 3-4 drops of water directly over the center of the hole. Set on a paper with print.
- Tell your students to carefully lift the magnifier and set it down on top of the paper.
- Students should then look straight down through the top of the water drop. The printing on the paper will appear magnified. By pressing down on the cardboard, students can focus the print.

### Student Discussion Questions:

- What does the lens do to the object? *It makes the object look bigger.*
- What type of lens did you make with the water magnifier? *Convex lens*
- If the letter does not look clear, you can press down on the cardboard stage. What are you changing? *You are changing the focal length.*

## LESSON 3: Disappearing Penny

### Lesson Materials:

- Bowl
- Penny (or other coin)
- Water

**Procedure:**

- Glue a penny in the bottom of a bowl.
- Look at the penny, then step backward until the penny is just out of your view.
- Stay in that spot.
- Have your partner pour water into the bowl.
- Keep looking at the bowl and penny will appear.

**Student Discussion Question:**

- How does this work? *You can't see the coin because some of the light rays that come from the coin are blocked by the cup and the other rays go above your eyes. When you put water in the cup, the light previously hitting your forehead bends down toward your eyes and the coin comes into view. The water causes the light rays to refract and changes the angle of the light.*

**LESSON 4: Mystery Balloon Pop****Lesson Materials:**

- Clear Balloon
- Black Balloon
- Magnifying glass
- Sunlight

**Procedure:**

- Partially insert the black balloon into the clear balloon. Make sure the opening to the black balloon is still accessible.
- Partially blow up the black balloon and tie it off. Push the black balloon the rest of the way into the clear balloon.
- Fully blow up the clear balloon and tie it off.
- Use the magnifying glass to focus the sunlight on the black balloon inside. The light rays should form a tiny point of light on the black balloon.
- The black balloon should pop.

**Student Discussion Question:**

- How does this work? *In the clear balloon, most of the heat passes right through the balloon's surface. The black surface of the balloon on the inside absorbs all of the light energy. The energy is transformed from light to heat. The focused sunlight transferred to thermal energy causes the bonds of the balloon to weaken and the balloon explodes.*

## LESSON 5: Disappearing Jelly Marbles

### Lesson Materials:

- One teaspoon jelly marble crystals – hydrate marbles for a minimum of 8 hours before this demonstration in distilled water
- Clear container
- Small sticker or sign that will fit under clear container

### Procedure:

- Place a small sign under the clear container. Do not let students see you doing this.
- Place one layer of hydrated jelly marbles in the bottom of the clear bowl.
- Have students make observations about the jelly marbles.
- Slowly pour water into the bowl covering the jelly marbles.
- As you fill the bowl, the sign under the bowl will become clear.

### Student Discussion Questions:

- How does this work? *Jelly marbles are made out of a superabsorbent polymer that absorbs 300 times its weight in water. These spheres can be up to 99% water. When light passes through them, it is bent or refracted the same amount as light entering plain water. You can see the edges of the sphere because the light is refracted a slightly different angle at the edges.*
- What is the Angle of Refraction? *When the Incoming light ray enters a new material, it is bent toward the normal (a virtual perpendicular line coming from the surface). The angle depends on the type of material. It is unique for each type of material. The degree the light ray changes angles is the Angle of Refraction.*

## LESSON 6: Spectroscope

### Background Information:

A spectroscope is a scientific instrument that splits light into its different wavelengths, which humans see as different colors. Violet has the shortest wavelength that people can see and red the longest. This instrument can also identify wavelengths that humans cannot see, such as infrared and ultraviolet radiation. Light usually contains a mixture of different wavelengths. By studying these, scientists can find out useful information, such as the chemical elements present at the source of the light. Spectroscopes are widely used in astronomy, chemistry, and other areas.

Joseph von Fraunhofer, a German optician, invented the spectroscope in 1814. In its early form, it used a lens to focus incoming light and a prism to split the light by refraction. Later, however, Fraunhofer replaced the prism with a device consisting of a number of narrow, parallel slits known as a diffraction grating. This spread out the different wavelengths of light by differing amounts and had the advantage of allowing the observer to actually measure the wavelengths, which was not possible using a prism. Fraunhofer used his spectroscopes to study light from a variety of sources, including flames, hot materials, the Sun, planets and stars. *From Wisegeek.com*

**Lesson Materials:**

- Handout pattern of spectroscope (print pattern on darkest cardstock available)
- Section of CD – teacher can cut up a CD in required size sections with a scissors
- Scissors
- Tape
- Glue
- Light sources

**Procedure:**

- Follow assembly instructions on pattern.
- When complete, the student should look through the hole in section F. The slit in section C should be directed toward a light source.
- Look at several light sources such as natural sunlight, fluorescent light, computer monitor, sodium vapor (yellow), mercury vapor or neon lights.
- Compare the spectra produced.

**Student Discussion Question:**

- How does this work? *White light is made of all the wavelengths of visible light. The CD acts as a grating which splits the white light into the different color components. Each element has its own unique pattern of wavelengths when it is heated or burned. We see different color patterns and black bands when observing different sources of light.*