RAFT IDEAS

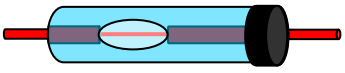
Topics: Light, Optics, Refraction

Materials List
- ✓ Clear, sealable, cylindrical tube
- ✓ Thin, colored straw
- ✓ Block printing of capital letters
- ✓ Water

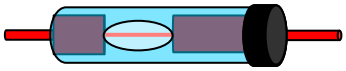
This activity can be used to teach:
- Light reflecting from objects and entering the eye allows objects to be seen (Next Generation Science Standards: Grade 4, Physical Science 4-2)
- Waves are reflected, absorbed, or transmitted (Next Generation Science Standards: Middle School, Physical Science 4-2)

Bubble Lenses

Getting an angle on light!

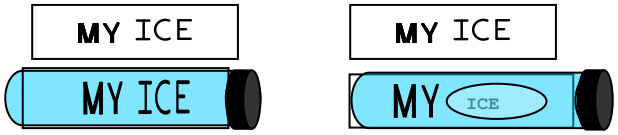


Cylinder on the straw



Cylinder lifted up

Figure 1



Cylinder on top of printed letters

Cylinder lifted up

Figure 2

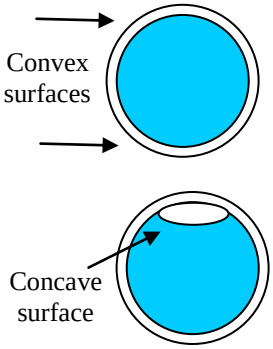
Use a water filled cylinder and a bubble to create convex and concave surfaces. Make light rays move closer together (converge) or move apart (diverge).

To Do and Notice

1. Fill a clear, cylindrical container with water. Leave a little air inside. Seal the top.
2. Place the cylinder on a thin colored straw as shown in figure 1. Slightly tilt the cylinder until the air bubble is over the straw. How does the straw look as seen through the cylinder and the bubble?
3. Slowly raise the cylinder above the straw until further away than the diameter of the cylinder. How does the straw appear to change? See figure 1.
4. Place the cylinder horizontally over some block printing of capital letters. Slowly raise the cylinder above the printing, higher than the diameter of the cylinder. Does the printing appear to change height, width, and/or orientation? Do all the letters seem to change in the same way? See figure 2.
5. Position the cylinder as stated in step 4 and slightly tilt the cylinder until the air bubble moves over the line of printing. How do the letters appear in the bubble?
6. With the bubble over the printing raise the cylinder as in step 3. Do the images of the letters change in the same way as the image of the straw in step 3?

The Science Behind the Activity

Light travels in straight lines through transparent uniform material (air, water, plastic). Light bends (refracts) when crossing the boundary between materials with different indexes of refraction, except for light rays that cross perpendicular to the boundary. Curved boundaries (the materials' surfaces) can make light either converge, if thicker in the middle than the edges (convex), or diverge, if thinner in the middle than the edges (concave). Clear convex surfaces can create magnified images when held near an object. When the distance between them is greater than the focal length of the convex surface, the object will appear flipped (inverted). Some letters have horizontal symmetry and will look the same when flipped, such as the capital letters O, I, E, and C. Note concave surfaces do not create inverted images. In step 2, the convex surfaces of the cylinder and water will magnify the width of the straw. The concave boundary of the water formed by the bubble of air will create an image of the straw with a narrowed width. Similarly the letters in steps 4, 5, and 6 are enlarged by the convex and reduced by the concave surfaces. See the next page for simplified light ray diagrams that illustrate the bending of the light rays.



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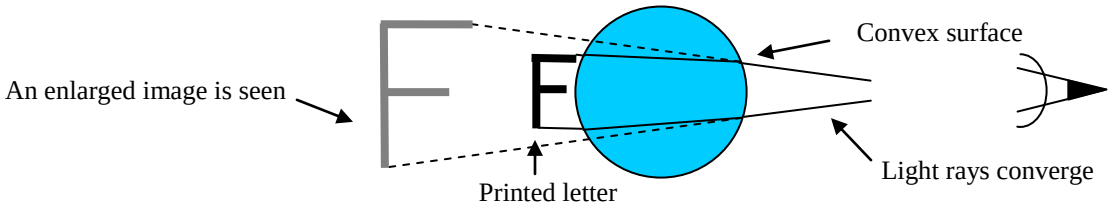
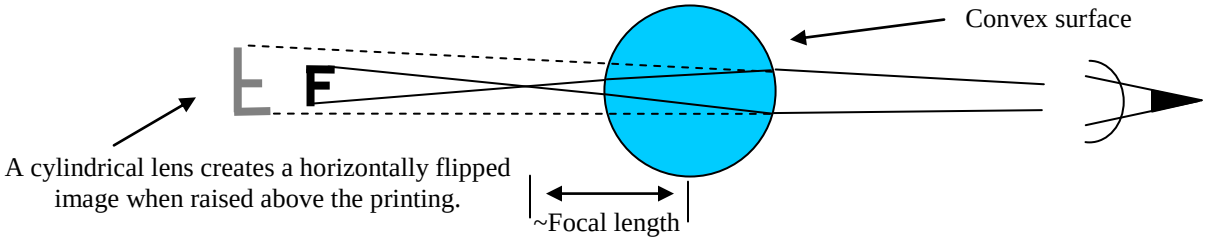
Developed and written by Michael Pollock (RAFT)

Simplified light ray diagram (rotated view, not to scale)



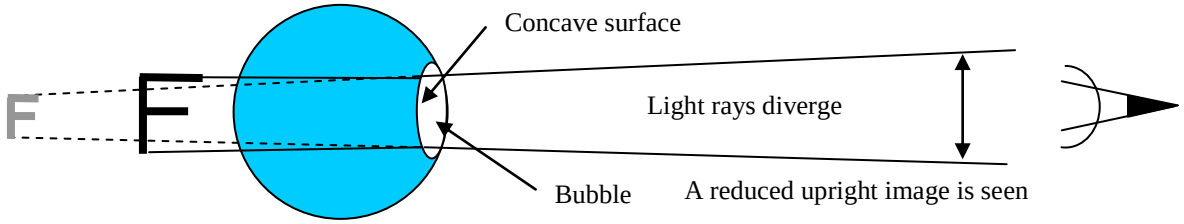
Simplified light ray diagram (rotated view, not to scale)



A liquid filled cylinder will magnify the dimension of the object that aligns with the curved surface of the cylinder, as shown above. In step 2 of **To Do and Notice** the straw's image increases in width and not in length. In step 4 of **To Do and Notice** the image of the letters increased in height but not in width (figure 2). Note the light rays are converged by both the entry and exit surfaces of the cylindrical container.

The air bubble creates a concave surface in the water in the cylinder (see below) such that the light rays will diverge, even though the convex surfaces above and below are converging the light rays. The width of the straw and the height of the letters appear reduced in size but not flipped. The reduction, due to the concave surface of the liquid, is counteracted by the magnification due to the convex surfaces of the liquid/container so the image does not seem to shrink much as the distance between the object and the cylinder is increased. With a regular concave lens, the image size would be further reduced as the distance between the two was increased.

Simplified light ray diagram (rotated view, not to scale)



Taking it Further

Fill a cylindrical container almost full with water and then add mineral oil ("baby oil"). How are the observations through the bubble of mineral oil different than for a bubble of air? Mineral oil has an index of refraction that is slightly greater than water, whereas the index of refraction for air is less than water. A bubble of mineral oil in water will converge, not diverge, light rays creating magnified images.

Web Resources (Visit www.raft.net/raft-idea?isid=507 for more resources!)

- Convex and concave lenses - http://www.ddart.net/science/physics/physics_tutorial/Class/refrn/U14L5a.html
- Index of refraction activity - http://www.exploratorium.edu/snacks/disappearing_glass_rods/index.html