RAFT IDEAS

Topics: Light, Optics, Refraction

Materials List

- ✓ Dark surface or material
- ✓ Thin straw or water dropper
- ✓ Clear media tray from a CD jewel case, one having a solid center "star" is preferred, or equal
- ✓ Clear, short, flat-bottomed vial with a small diameter
- ✓ Block printing
- ✓ Printed picture
- ✓ Piece of fabric
- ✓ 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)

raft resource area for teaching
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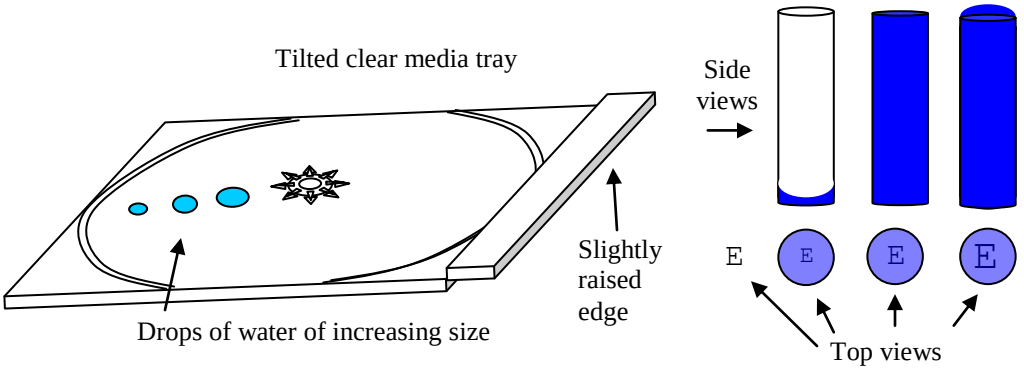
Drop and Vial Lenses

Make convex and concave lenses from water!



Use drops and vials of water to create convex and concave surfaces. Make light rays move closer together (converge) or move apart (diverge).

To Do and Notice

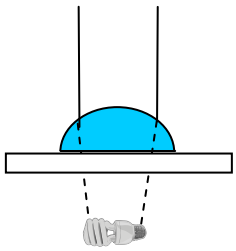
1. Find a location on a desk or table that has overhead lighting. Place a clear media tray, CD side upward, onto a dark colored surface or material on the desk or table.
2. Use a thin straw or a dropper to put 3 drops of water of increasing diameter (3 mm (1/8") and up) on the CD side of the clear media tray as shown above.
3. Tilt the media tray, as shown, and note, for each drop, at what elevation a focused image of the overhead light source is formed on the dark surface below.
4. Place the media tray and drops over a picture and/or a piece of fabric. Tilt or raise the media tray and notice how the item looks through each sized drop.
5. Place a small drop of water on the clear central "star" of the clear media tray, if present. Examine the picture and fabric in the same way as in step 4.
6. Place a clear, small, flat-bottomed vial with a diameter of 2 cm (3/4"), or smaller, over a printed letter. Add drops of water until a concave water surface is created, as shown in the leftmost vial above. Look down through the water and raise the vial. Does the letter change? Put the vial back down over the letter.
7. Fill the vial until the water is level with the top. What size is the letter now?
8. Raise the vial as was done in step 6. Does the letter change?
9. Add a drop at a time to overfill the vial. The surface will bulge forming a convex surface. How does the letter's size change as drops are added?
10. Raise the vial as was done in step 6. Does the letter change?

The Science Behind the Activity

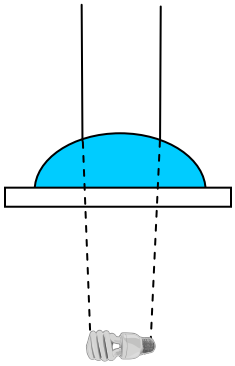
Light travels in straight lines through transparent uniform material (air, water, plastic). Light bends (refracts) when crossing the boundary between materials with different indexes of refraction, except for light rays that cross perpendicular to the boundary. Curved boundaries (the materials' surfaces) 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. The greater the degree of curvature, the shorter the focal length; and the greater the magnification. As the diameter of a water drop decreases, the increased curvature will create a focused image closer to the drop. See the next page for simplified light ray diagrams covering the different situations.

Developed and written by Michael Pollock (RAFT)

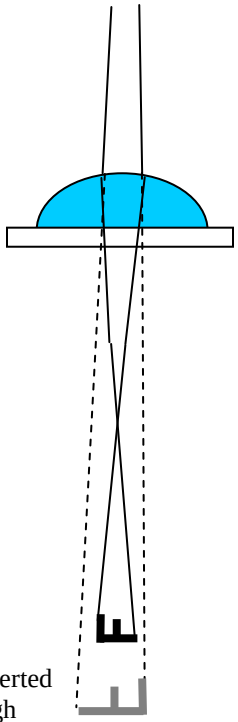
Simplified light ray diagrams (not to scale)



A small drop has a greater curvature and creates a focused image near the drop



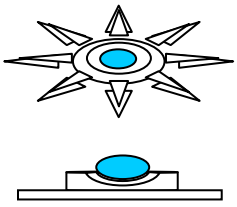
A larger drop has less curvature and creates a focused image at a greater distance from the drop



A convex surface creates an inverted image when raised far enough

When the distance between the drop and the letter is greater than the focal length of the convex surface of the drop, then the letter will appear flipped (inverted). Note that concave surfaces do not create inverted images.

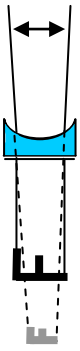
The solid "star" at the center of some media trays is slightly curved downward so that a drop of water in the center will be curved on both the top and bottom. The double curvature will provide increased magnification.



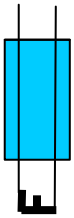
Cross section view

Water's "stickiness" (surface tension) creates a concave surface meniscus in a partly filled vial. The degree of concaveness depends on the vial's diameter and depth of the water. The letter will appear reduced in size.
In a filled, but not over-filled, vial the light rays cross the air/water boundary at a 90º angle and thus will not change direction. As a result a letter will appear unchanged in size and orientation.
The water surface on an over-filled vial will form a convex surface that will create magnified images, see below.

Light rays diverge

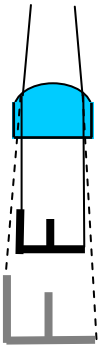


A reduced image is seen



The letter is seen as unchanged in size

Light rays converge



An enlarged image is seen

Taking it Further

Fill the vial with another liquid such as mineral oil that has a different index of refraction than water and note the variances in images.

Web Resources (Visit www.raft.net/raft-idea?isid=508 for more resources!)

- Anatomy of a Lens - http://www.physicsclassroom.com/class/refrn/Lesson-5/The-Anatomy-of-a-Lens
- Ray Diagrams for Lenses http://hyperphysics.phy-astr.gsu.edu/hbase/geoopt/raydiag.html