

EQUIPMENT BUILD PLAN

LIGHT & OPTICS

Water Lens

Word Flip

A clear plastic tube rests in a wooden cradle above a printed label reading ALUMINUM OXIDE. Empty, the tube changes nothing; filled with water, it becomes a cylindrical lens that flips both words top to bottom, but only one of them looks different. It is a quick, memorable discrepant event for any unit on lenses and images.

Written from Bruce's original workshop handout. Bruce's final review of this plan is in progress.



DIFFICULTY	BUILD TIME
Beginner	1-2 hours
COST	SAFETY
About \$10-15	Everyday care
GOOD FOR	
Teachers, Families, Makers	

What it shows

Fill a clear tube with water and one word on the sign turns upside down while the word next to it stays perfectly readable.

Key ideas: converging lenses, inverted real images, refraction, symmetry

Safety (Everyday care). An adult should do any sawing of the wooden cradle. Use a plastic tube rather than glass so a dropped, water-filled tube cannot shatter. Wipe up spilled water so no one slips.

CONSTRUCTION

Build it

Materials

- ☐ **Clear rigid plastic tube** · 1, about 2 ft long and about 1 1/2 in diameter
Size is flexible; a clear 2-liter soda bottle also works
- ☐ **Rubber stoppers to fit both ends of the tube** · 2
- ☐ **Scrap wood for a base board** · 1 piece, a little longer than the tube
- ☐ **Scrap wood blocks for the end cradles** · 2
Each gets a curved notch the tube can rest in
- ☐ **Printed label: ALUMINUM in green and OXIDE in red** · 1
Use plain block capital letters
- ☐ **Water** · enough to fill the tube

Tools

Saw (hand saw, band saw or scroll saw)

Drill with a hole saw or spade bit (optional, for the cradle notches)

Sandpaper

Color printer

Wood glue or small screws

1

Choose the tube

Pick a clear plastic tube with smooth, undistorted walls and stoppers that fit both ends snugly. A clear 2-liter soda bottle with its cap is a no-build alternative for a first try.



2

Cut the base and cradles

Cut a base board a little longer than the tube. Cut two end blocks and give each a curved notch so the tube rests securely across them.

3

Set the height

Fasten the end blocks to the base with glue or screws. Bruce's cradles hold the tube about 3 inches above the label; if your tube has a different diameter, adjust the block height so the words appear sharply flipped when viewed from normal standing distance.

4

Print the label

Print the words ALUMINUM OXIDE in large block capitals, with ALUMINUM in green and OXIDE in red. The two colors are a deliberate red herring.

5

Mount the label

Glue the label to the base board, centered under where the tube will lie, with the words running along the length of the tube.



6

Test it empty

Lay the empty, capped tube in the cradle and look down through it. Both words should read normally; an empty tube does not bend the light much.



7

Fill the tube

Stopper one end and fill the tube with water at a sink. Top it off until the water bulges slightly at the open end, then push in the second stopper so no air bubble is trapped. It takes a little practice.



8

Run the demonstration

Set the filled tube back in the cradle. ALUMINUM now appears upside down while OXIDE still looks right side up. Let viewers guess why before explaining.



THE PHYSICS

How it works

A tube full of water is a cylindrical converging lens. Light passing through it is bent toward the center of the tube, but only in the direction across the tube, not along it.

When the label sits farther from the tube than the lens's focal length and you look from a distance, you see a real, inverted image. Because the tube only focuses across its width, the image is flipped top to bottom, not left to right.

Both words are flipped. ALUMINUM looks wrong because letters such as A, L, U, M and N do not look the same upside down. Every

Using it

- Show the empty tube first, then fill it in front of the class. Ask: Why did one word flip and the other didn't? Does the color matter?
- Have students test the color idea by writing OXIDE in green and ALUMINUM in red.
- Challenge students to invent other words that survive the flip, using only top-to-bottom symmetric

letter in OXIDE is symmetric top to bottom, so its flipped image looks exactly like the original. The color of the ink has nothing to do with it.

The empty tube has thin walls with nearly parallel surfaces, so it barely bends the light, and the words pass through unchanged.

letters (B, C, D, E, H, I, K, O, X), such as CHECKBOOK or DECODE.

- Raise and lower the tube, or move your eye closer, to find where the image switches from upright to inverted. That point relates to the focal length.
- Compare the tube with a glass marble or a round flask, which focus in both directions and so flip the image both top to bottom and left to right.

GO FURTHER

Variations

- Instead of a glass or plastic tube, Bruce notes that a clear 2-liter soda bottle filled with water and capped works too.
- Make several labels with different word pairs and let students predict which words will appear to flip.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

Both words look blurry rather than flipped.

TRY THIS

Change the distance between the tube and the label, and view from farther away. The effect depends on the label being beyond the lens's focal point.

IF THIS HAPPENS

An air bubble spoils the view.

TRY THIS

Fill the tube until the water domes at the top, then press the stopper in at an angle so the excess water pushes out the air.

IF THIS HAPPENS

The stoppers leak.

TRY THIS

Use a snugger stopper size, or wipe the tube ends dry before inserting the stoppers.

© Bruce Yeany · Homemade Science with Bruce Yeany · youtube.com/@YeanyScience

Free for personal and classroom use. Please don't resell or republish. Build and use at your own risk; follow the safety notes and supervise children.