*Note: If you are following along with Virtual EYH, you only need the arrows on page 2

Bending Light Activity Guide

Activity 1: Flip-Flopping Arrows

Materials:

- A clear glass of water
- Print-out of attached arrows

Instructions:

1) Hold the paper so that the blue arrow is on top and pointing to the right.
2) Hold the glass at about arm's length and pass the paper behind the glass of water from right to left and observe which direction the arrows appear to point.

The blue arrow seems to point: right left

The red arrow seems to point: right left

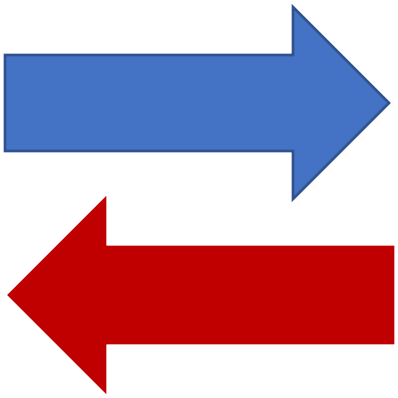
3) Change the distance between you and the water glass and repeat a couple times moving closer to the glass. Observe which directions the arrow seems to point when you are close to the glass.

The blue arrow seems to point: right left

The red arrow seems to point: right left

Can you think of why this might be the case?

*Note: If you are following along with Virtual EYH, you only need the arrows on page 2



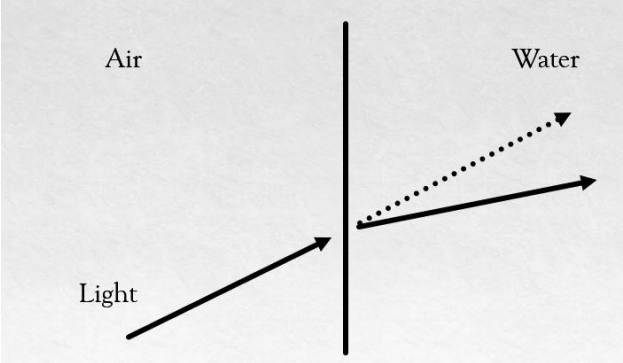
*Note: If you are following along with Virtual EYH, you only need the arrows on page 2

What's Going on Here?

Two things are actually happening.

1) Diffraction

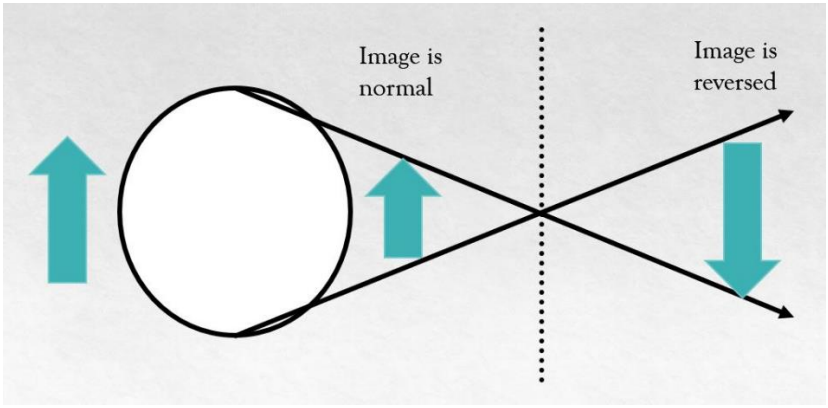
The shape of the arrows is distorted because light bends when it moves between different materials (for instance air and water). When light approaches the water glass, you would expect it to just keep going straight through, as shown by the dotted line. After all, water and air are both transparent.



However, light moves slower in water than in air. The molecules in water are a lot closer than in air, and it's a lot harder for the light to make its way through without bouncing off of something. Think about it: is it easier to move your hand through water or air? Well, light has a similar problem.

When light moves into the water glass from the air at an angle, part of it slows down first, causing it to turn. Imagine a car: if you slow down the wheels on only the left side, the wheels on the right will push the car forward faster and the car will start to turn towards the left. So instead of going straight through the water glass, the light bends, distorting the shape of the arrows.

2) Lenses



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The curved glass acts as a lens. The lens focuses the light from the arrow as shown in the figure below. However, note that the rays of light from the two ends of the arrow cross, at a distance known as the focal length of the “lens” formed by the curved glass. Beyond the focal length, the light from the tip of the arrow is below the light from the end of the arrow instead of above. This means that the arrow will appear upside down when you are far from the glass and right-side up when you are close to the glass. This is why the arrows look normal when you are close to the glass but the arrows flip when you are far away.

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Activity 2: Creating a Curved Stream of Light

Materials:

- Empty soda can
- Bright flashlight
- Sharpened pencil
- Sink (preferably in a dark room)

Instructions:

1) Poke a hole in the side of the can near the bottom.
2) Hold your finger over the hole and fill the can with water.
3) Hold the flashlight over the top of the can and try to seal off as much of the light from escaping out the top as possible with your hand.
4) Turn off the lights, hold the can over the sink (it will be easier to see if the can is lower in the sink) and take your finger off the hole.
5) Observe the stream of water.

What do you notice about the light?

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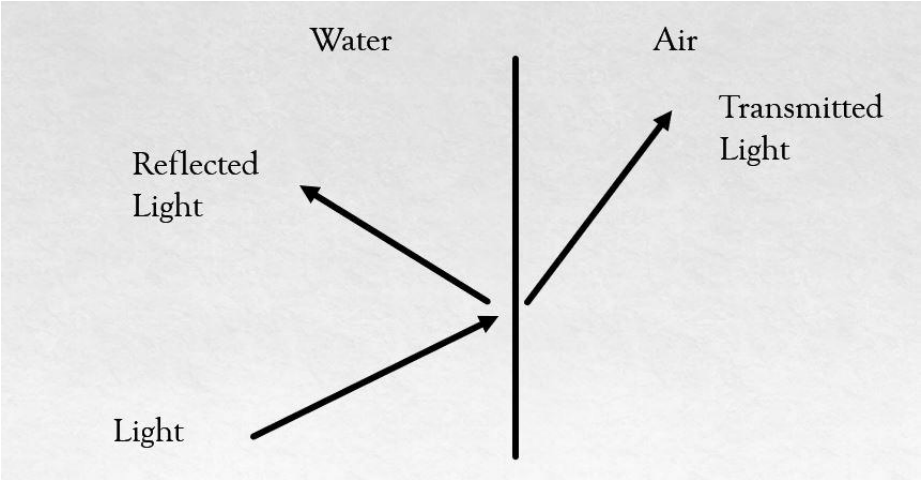
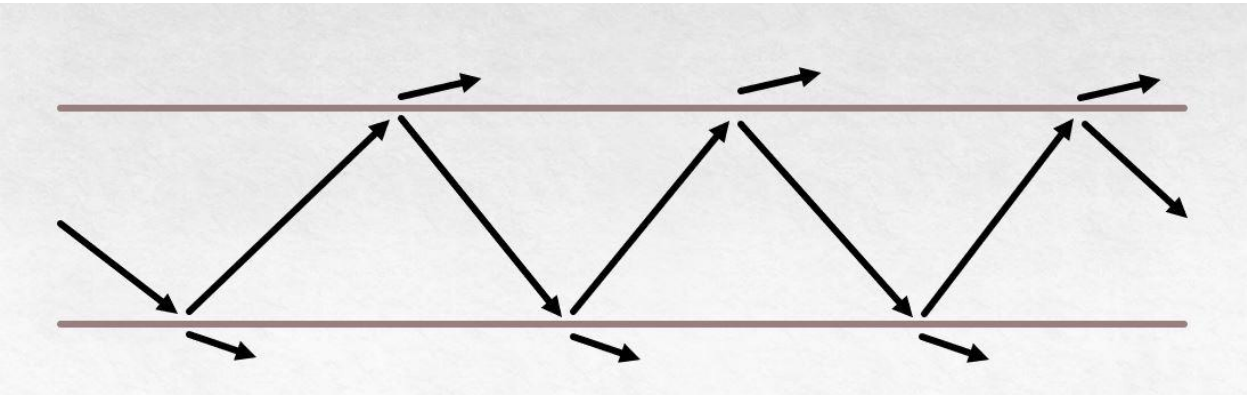
What's Going on Here?

The light follows the stream of water. So somehow, the water is bending the light. How does it do that? Well, the light is actually reflecting off the water, which keeps the light trapped within the water stream. But there don't seem to be any mirrors here, right?



Well, the initial picture of diffraction I provided in the previous activity is incomplete. Yes, when light moves from one material to another, the light that passes through will turn in a different direction. However, as shown in the figure above, not all of the light will pass through the interface (an interface is where two different materials meet). The light that passes through is called "transmitted light". The light that bounces back is "reflected light". So even though a water/air interface doesn't look like a mirror, it still reflects a large portion of the light stream. As shown below, the light bounces back and forth between the two sides of the water stream, thus effectively trapping a significant portion of the light in the stream of water. So the water guides the light.



Fun fact: this is how fiberoptic cables (anybody heard of Fios internet) work. They carry light in order to pass information.

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Activity 3: Splitting Light

Materials:

- DVD
- Compact/hand mirror
- Flashlight
- Wall

Instructions:

1) Find a blank wall. Hold the mirror at an angle and reflect the flashlight beam onto the wall using the mirror. Change the angles of the mirror and flashlight.

What do you observe about the reflected light? Does changing the angles change anything significantly?

2) Do the same thing with the DVD, being sure to change the angles.

What do you observe about the reflected light? How does it change with angle? How is it different from the mirror?

Why do you think the DVD is different from the mirror?

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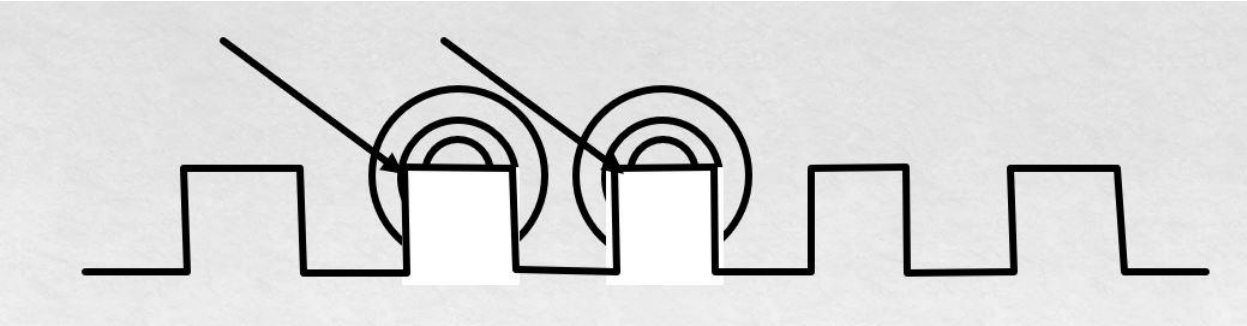
What's Going on Here?

Both the mirror and the DVD are flat and reflective. So why does the reflected light look so different? It turns out DVD's are actually not flat! The DVD actually has a series of rings (like a target) of very small bumps. These bumps store the information for the movie on the DVD.



When light hits each bump, the light is scattered in all directions, as shown in the figure below. Light scattered from different bumps interferes, since light is a wave. Imagine dropping two rocks into a lake: you will create waves. At first, you will see two perfect circles of ripples. However, once the ripples meet, the pattern will be distorted.

The same thing happens here. Where the waves overlap, they interfere, meaning the size of the wave adds together. So two waves that are both at the peak will make a peak that is twice as high (called constructive interference) whereas two waves where one is at the peak and one is at the trough will cancel out and the water will just be flat (called destructive interference).

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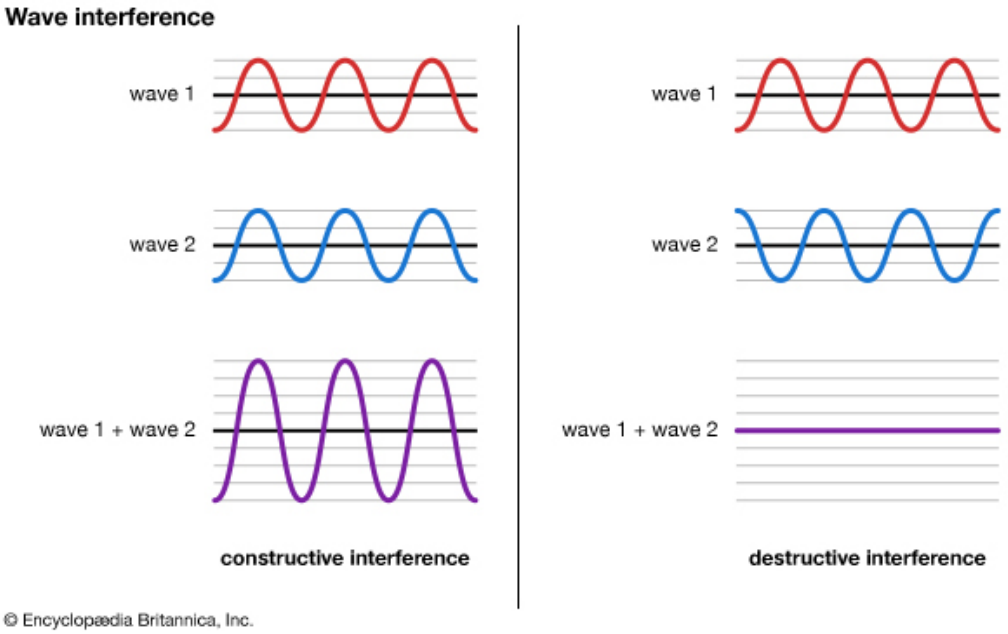

Now, white light, like the light from a flashlight, is actually made up of every color of light. Different colors of light have different wavelengths (meaning the peaks are closer together or farther apart). Red light has the furthest peaks while purple light has the closest. Since the peaks for different colors are in different locations, the places where they interfere constructively (add together) and destructively (cancel out) will be different in different locations. So that means different colors will be brighter in different locations. That is what effectively splits the light into different colors and generates a rainbow!