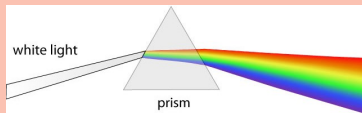


Activity #2: Refraction

In the image here, you can see a pencil partly in a cup of water. The half in the water looks separate from the half out of the water. What is causing that? It's a property of light called refraction! Refraction is important for lenses, prisms, and optical fibers, and is the science behind rainbows!



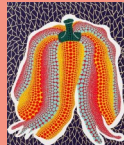
You may have heard about the speed of light, $c = 186,000$ miles/s (pretty fast!). More specifically, this is the speed of light in *vacuum* - like in space! - where there's no matter. But actually, light travels slower in a material, like water, air, and glass. That has an interesting effect on the path the light travels: when it goes between the two materials, it bends, just like in you can see the light doing in the prism below.



We can also see that white light (which is the combination of all the colors) that goes into the prism and it comes out as a rainbow. This is also the work of refraction! Not only does light bend when it travels between two different materials, but different colors of light bend by different amounts! So blue light bends more than red light as it travels from air to glass.

Yayoi Kusama (1929 -) Artist

Yayoi Kusama is a colorful and vibrant Japanese artist who uses mirrors in many of her art installations. In recent years, her Infinity Mirror room installations have been immensely popular - being both interactive and Instagram-worthy photoshoot opportunities. Kusama's art is also heavily influenced by her mental health, especially her obsessive-compulsive order and hallucinations. Since 1977, she's voluntarily lived in a psychiatric ward in Japan.



Activity #2: Refraction

In the next activity, let's explore some of these properties of refraction.

Materials provided in kit:

- Keychain flashlight
- Prism
- Arrow printout

Materials you'll need to find:

- Water in a clear jar or glass

Directions:

1. Set the paper with arrows upright.
2. Place a jar or glass about 6 inches in front of the paper
3. Pour in the water. What happened?
4. Now flip the paper over to the side with colored bars. What do you see? The image is flipped because of the light bends as it goes between the air and water.

3



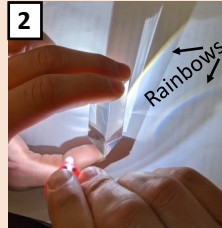
Exploration:

1. Does it make a difference how close the water is to the paper?
2. Does it make a difference if the jar is square or round? What about the size of the jar or glass?
3. Can you draw a diagram of what you think is happening to the light rays as it goes from the air to water?

Directions continued:

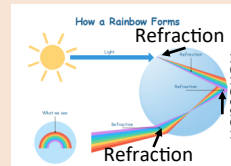
1. Let's make a rainbow! Take your prism and the keychain flashlight.
2. Shine the flashlight through the long side of the prism. Have something white, like a piece of paper, on the other side of the prism and see the rainbow that appears on it.

2



Exploration:

1. Does it make a difference how close the flashlight is to the prism?
2. Can you find other material to shine the flashlight through to make a rainbow?
3. To the right is a diagram showing what happens with rain droplets to form a rainbow in the sky. It's both refraction and reflection!



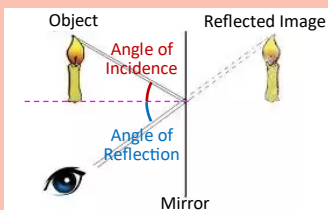
Shine some light on optics

activities about reflection and refraction

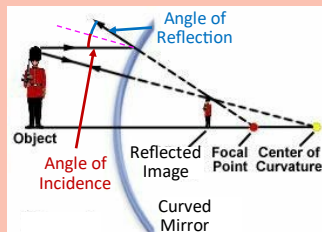


Activity #1: Mirrors

We see reflection all around us, from our bathroom to the car mirrors. When light reflects off a surface, it always follows the same rule: the **angle of incidence** is the same as the **angle of reflection**. Using this rule, we can see that the reflection of the candle (what our eye sees) would appear to be on the other side of the mirror.



Like the diagram above, this is easy to see with a flat mirror, but the same rules apply with curved mirrors too! If we look at the diagram below, the light still follows the **same rule**: the angle of incidence is the same as the angle of reflection. We can again use the law of reflection to find where our eye would see an object in the mirror, and it's change in size. For the example below, we would see the soldier on the other side of the mirror and the reflection would appear much smaller!



We use these curved mirrors in a few different ways. We see curved mirrors on side view mirrors in cars, where they allow a larger field of view of the

road. The reason they say "objects in mirror are closer than they appear" is because the image is smaller, just like above, and looks like it's farther away!

Check out our project page for more information, like:

- A blog sharing finished projects by other kids
- Interviews with artists and scientists who study perception!
- And more!



kohlerfellows.illuminatingdiscovery.wisc.edu/perception-connection/

Activity #1: Mirrors

In this activity, you'll make a curved mirror and explore what it does to images placed below it.

Materials provided in your kit:

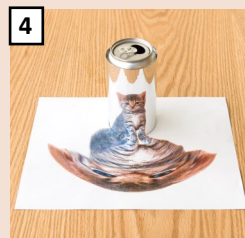
1. Piece of reflective Mylar
2. Distorted ("morphed") images
3. Anamorphic Grid diagrams

Materials you'll need to find:

1. Soda can or glass
2. Tape
3. Pencil or markers

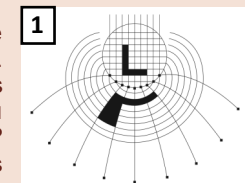
Directions:

1. First look at one of the distorted images. Can you tell what they are? Let's find out!
2. Make a cylindrical mirror (a mirror shaped like a cylinder) by wrapping the Mylar around a soda can or glass. It should be loose enough so that it doesn't reveal the wrinkles and imperfections in the can's surface.
3. Try to make the surface of the Mylar as smooth as possible, and then use tape to hold it in place.
4. Place the Mylar-wrapped can in the circle next to one of the morphed images. Look at the reflection of the image in the curved mirror. What does it look like now? How has the mirror changed the image on the page? A mirror that distorts a reflected shape is called an *anamorphic mirror*.



Exploration:

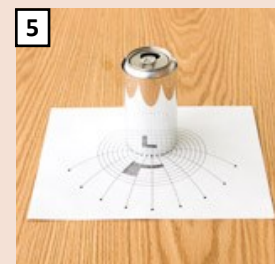
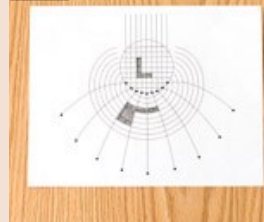
1. Now take a look at the anamorphic grid print out. How do you think the grid's reflection will look when you place the mirror in the circle? Try it and see what happens to the curved lines.
2. Remove the can and draw a picture on the grid of squares inside the circle. We show an example of an L. But you can do more elaborate designs as well!
3. Now you can change your design into anamorphic art! Just copy what you've drawn in each square in the circle to the corresponding "square" on the curved grid.



Activity #1: Mirrors

4. Copy one square at a time. Count how many empty squares are between your original shape and the circle (which represents the surface of the mirror, or the origin of your reflection), and then start drawing your shape the same number of "squares" away on the outside of the circle (see photo below).

3+4



5. Keep counting and filling in squares as you map the complete reflection of your design onto the curved grid. When you're finished, check your design by placing your mirror back on the circle.

Have a cool project to show?
Learn something new from
these activities you want to share?
Tell us about it here →



Donna Strickland (1959 -) Physicist

Dr. Donna Strickland is a Canadian optical physicist, meaning she studies light and how to manipulate it. Specifically, she works with high powered lasers and discovers new ways to make very short, high powered laser pulses, which is very important in optical surgeries, machining processes, and medical imaging. In 2018, Dr. Strickland was awarded the Nobel Prize in Physics for this work, and is only one of four women to be awarded a physics Nobel Prize since the beginning of the prize over a hundred years ago.

