Name _____

Refraction

The change in direction of light as it passes from one medium to another caused by a change in its speed

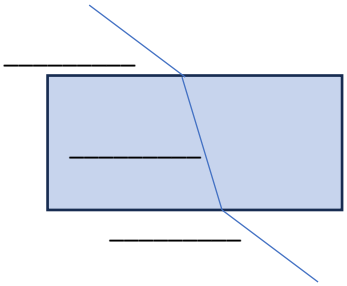
From our "Reflection" lab last week:

What is the name of the ray that hits the mirror? _____

What is the name of the ray that reflects off the mirror? _____

Demonstration: Refraction in Water

There are three important rays in refraction. What are they?



Which way will the ray bend as it exits the water and enters the air?

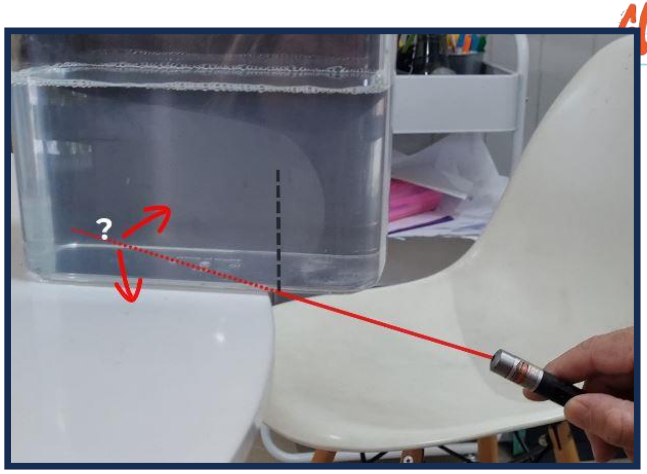
_____

Why did the light bend when it entered the water?

_____

Experiment 1: Refraction in Water

Before conducting this experiment complete the hypothesis based on the image below. Notice that the ray is entering the container from the *bottom*. The dotted black line is the normal line. Based on what we have seen so far, complete the hypothesis describing which way the ray will bend once it enters the *water* at the angle shown:



Hypothesis:

IF…the incident ray strikes the container from the bottom

THEN… _____

BECAUSE… _____

Experiment 2: Get Rid of the Germs!

Review:

- ✓ What is the name of the bent ray? _____
- ✓ What is the difference between reflection and refraction? _____
- ✓ When travelling from air to water, light bends _____ the normal.
- ✓ Why does light bend in a medium? _____

Teacher Notes

Refraction

The change in direction of light as it passes from one medium to another caused by a change in its speed.

From our "Reflection" lab last week:

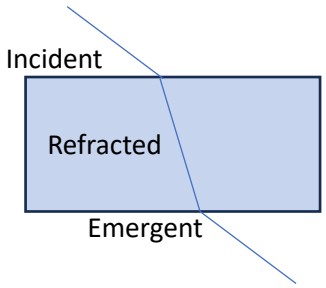
What is the name of the ray that hits the mirror? _____

What is the name of the ray that reflects off the mirror? _____

Demonstration: Refraction in Water

I used a small Tupperware container filled with water and added some liquid bleach, just enough to allow the ray to become visible in the water. You can also use a glass or plastic block if you have them. Or you can use the same container that will be required in experiment one.

There are three important rays in refraction:



Which way will the ray bend as it exits the water and enters the air?

The ray will move *away* from the normal.

Why did the light bend when it entered the water?

Because of a change in its speed. In this case, it slowed down.

Teach

First draw the diagram above on the board and explain what each of the three rays do. The *incident* ray is the ray that strikes the surface, just like in reflection. The *refracted* ray is the ray that is bent inside the medium (explain to the students what a "medium" is as in the video). The *emergent* ray is, just as the word suggests, the ray that exits the medium.

Now have students fill in the three blanks on their lab.

Point the laser directly onto the side of the bottom of the Tupperware container (perpendicular to its surface) so that the ray goes straight through without bending. Then slowly change the angle of the ray so that the refracted ray begins to bend inside the medium. Have the students point to the different rays and tell you what they are called.

Ask the students “why” the light is bending and to write their answers in the blank. The reason for this is described in the definition above and results from a change in the speed of light as it enters the medium. But see if they can remember this without you telling them!

As it turns out, when light leaves a less dense medium (like air) and moves into a denser medium (like water, plastic, glass), it slows down by about 30%!

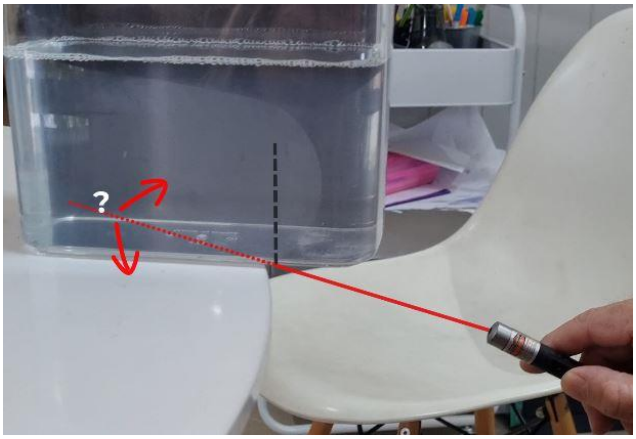
Exactly “why” light slows down is theoretical and so we will not discuss it here, but what we can do is qualitatively describe the refraction phenomenon and allow the students to make some predictions based on their observations.

First, show them that the refracted ray always bends in towards the normal (a line that is perpendicular to the surface: they should know this from the reflection lab) whenever the medium that the ray is entering is denser than the medium the ray is coming from. For example, if the ray is going from air into water, it will bend towards the normal. But if it is going from the water to the air, then it will bend away from the normal!

Experiment 1: Refraction in Water

For this experiment, you will need some kind of glass jar or container that can be sealed shut. Fill the container with water and a little bit of liquid bleach. Just enough to give the water a very slight cloudy effect. Too much and the ray becomes diffused and unclear. You will want to create a refracted ray by pointing the laser into the glass at an angle greater than zero (see video). *Make sure the students fill out the hypothesis first*. Keep in mind that the students will not be able to see the incident ray since the air outside of the container is clear. But they should be able to see the difference between the direction of the laser (the device) and the direction of the beam as it enters the medium. If you want a better effect, add water to dry ice and it will begin to “smoke.” You can use this smoke to help see the ray as it enters the glass. You can also use an aerosol as I did in the video.

Before conducting this experiment complete the hypothesis based on the image below. Notice that the ray is entering the container from the *bottom*. The dotted black line is the normal line. Based on what we have seen so far, complete the hypothesis describing which way the ray will bend once it enters the water at the angle shown:



Hypothesis:

IF…the incident ray strikes the container from the bottom

THEN… the refracted ray will bend toward the normal

BECAUSE… the ray slows down in the denser medium

Now do the experiment. Make sure to have the students name all the rays as you point to them.

For the second part of this experiment, you need to get smoke into the air above the water. This allows the ray to be seen both in the water AND in the air (inside the container above the water). To do this, light some matches, blow them out, and slide the now smoking match sticks into the container and quickly screw on the cap (see video).

Now shine the laser through the container and into the water, making sure the ray hits the water/air surface at an angle (the air inside the container). You should now be able to see both rays, the one in the water and the one in the air. Since the ray is exiting a dense medium (water) and entering a less dense medium (air) it should now bend *away* from the normal.

Experiment 2: Get Rid of the Germs!

This experiment is just for fun. Have the students draw some germs using different colored markers on a plain piece of white paper. Place this piece of paper (about 15 cm x 10 cm) into a small plastic bag. Have them trace out their hand using a black marker on the outside of the bag over the illustrated germs. So now it looks like they have germs all over their drawn-out hand. Using a tall glass or plastic jug, and looking from the top down into the jug, emerge the plastic bag into the water. From the side, nothing looks out of place. But from the top, you will see the germs literally disappear! The sketched hand will be still be visible, but the “germs” are “washed away”!

This occurs because the polyethylene plastic bag acts as third medium through which the rays travel (so plastic, water, and then air). The traced hand only has two mediums (water and air). The extra plastic medium causes variant kinds of refraction (causing these light rays to refract away from your eye) which is why you can see the traced hand (these rays are hitting your eye) but not the germs when looking down on the container!