Polarization

Overview: This experiment uses a special filter to investigate the vibrating patterns of visible light to discover otherwise invisible stress fractures in objects.

What to Learn: Students will learn that light not only has a wavelength (which is also called frequency, or color) and intensity (brightness), but it also has a direction known as its polarization. Folks who spend a lot of time outdoors in the bright sun, like snow boarders and fishermen, use polarized lenses to "cut the glare" by reducing the light that gets reflected off water and ice.

Materials

- two pairs of polarized sunglasses
- tape (the 3/4″ glossy clear kind works best)
- window
- hard clear plastic objects, like disposable utensils, clear plastic cups, CD cases, etc.

Experiment

1. Open the glasses and line them up so that the lenses are facing each other.
2. Look through the glasses at a window.
3. Rotate one pair of glasses 90 degrees. The lenses should completely block the light at 90 degrees.
4. When the glasses are sitting on the table facing each other, they are aligned at zero degrees. At this point, they allow some light to pass through, but not all light.
5. Complete the table:

Polarization Data Table #1

Flashlight beam shining by itself	Flashlight shining through two parallel polarizing filters	Flashlight shining through two filters at 90˚ to each other

6. For the second experiment, you'll be using two polarized filters. Lenses from old polarized sunglasses work well. You can confirm they are polarized with the rotating test (step #5 above).

7. Hold up two polarizers parallel to each other so you can see light streaming through both.
8. Have your lab partner hold an object up in between the polarizers.
9. Rotate the polarizing filters until you see some beautiful patterns and colors emerge. You can bend and flex the object to see different colors.
10. What other items can you look at through the filters?

Polarization Data Table #2

Object between the polarizers (clear, hard plastic items)	**Draw the image you see:**

Reading

The wavelength of light is its frequency or color. Intensity of light is how bright or dim it appears, phase is its time shift, and polarization is its direction. Polarized glasses filter out any light that's not coming from a certain direction. It allows some of the light to go through, but not all. So polarized lenses are light filters. Because it varies in brightness depending on its stage, astronomers use polarizing filters to look at the moon. They can use rotating polarizing filters to adjust the amount of light entering the eye.

White light, like from the sun, vibrates in all directions. Polarizers are special kinds of filters that block out all light except for the ones that are vibrating in the vertical plane.

Polarization has to do with the direction of the light. Think of a white picket fence – the kind that has space between each board. The light can pass through the gaps in the fence but is blocked by the boards. That's exactly what a polarizer does. It filters the light depending on its direction.

When you have two polarizers, you can rotate one of the "fences" a quarter turn so that virtually *no* light can get through – only little bits here and there where the gaps line up. Most of the way is blocked, though, which is what happens when you rotate the two pairs of sunglasses. Your sunglasses are polarizing filters, meaning that they only let light of a certain direction in. The view through the sunglasses is a bit dimmer, as less photons reach your eyeball.

You use the "filter" principle in the kitchen. When you cook pasta, you use a filter (a strainer) to get the pasta out of the water. That's what the sunglasses are doing – they are filtering out certain types of light. Rotating the lenses 90° to block out all light is like trying to strain your pasta with two strainers that don't have their holes lined up, so it's more like a mixing bowl. Nothing is allowed to pass through.

Astronomers use polarizing filters to look at the moon. Ever notice how bright the moon is during a full moon, and how dim it is near new moon? Using a rotating polarizing filter, astronomer can adjust the amount of light that enters into their eye so they can see more detail on the surface without being blinded with too much light.

Stress Fractures: White light contains all the colors of the rainbow. When the white light hits the clear plastic object, it refracts the light into colors, and only the waves in the vertical direction make it through the second polarizer. When you squeeze or bend the plastic, you're changing the speed at which the light travels through the plastic, which changes the wavelength and also the color you see. You'll notice higher-stressed areas have lots of color changes and lower-stressed areas are only a couple of colors.

Exercises

1. Why do you need two polarizers to block the light completely?

2. How can you tell if your sunglasses are polarized if you only have one pair?

Answers to Exercises: Polarization

1. Why do you need two polarizers to block the light completely? (Polarizers block all light expect waves vibrating in the vertical plane. When you have two polarizers, you can rotate one so that you block both the vertical and the horizontal planes, so virtually no light passes through.)

2. How can you tell if your sunglasses are polarized if you only have one pair? (Looking through one of the lenses at a LCD display [which is also polarized], you'll see the light get dimmer and brighter as you rotate the sunglass lens.)