There's More to Light Than Meets the Eye

Classroom Activity: Making a Rainbow

This activity was developed by Philip Sadler as part of Project STAR, funded by the NSF.
It was first published as: Philip M. Sadler. Projecting Spectra for Classroom Investigations. The Physics Teacher, 29(7), 1991, pp. 423-427.

When white light from the Sun or a light bulb passes through a prism, the light splits into its component wavelengths. Collectively, these components of light are called a spectrum. It's what you see when there's a rainbow, in which case the droplets of water in the air act as the prism.

Materials:

- Transmission-diffraction grating (4-inch square sheet, available from scientific supply houses)
- Overhead projector or slide projector
- Two large books or magazines
- White wall or screen to project the rainbow on
- Ruler
- Red, blue, green colored filters - if possible, cut 1x4-inch pieces of the filters for each student

Part I

Demonstrate that white light is a mixture of many wavelengths of light. You can take this opportunity to follow a systematic, scientific method. One such method is: Ask a question, make a hypothesis, design and carry out an experiment, and check your results against the original hypothesis.

Part II

Investigate the properties of filters. Our eyes see all wavelengths of light in the visible window. Color filters create an even smaller sub-window inside the visible window. A red filter, for example, lets through red wavelengths of light, but blocks out the green and blue wavelengths. Many students have the misconception that filters somehow dye the light a certain color. Before starting this experiment, have the students look through the filters at an ordinary white light, such as light from the Sun or an incandescent bulb. (Filters are not perfect. They let through all of their own color, as well as some of the neighboring colors in the spectrum.)

Procedure:

To create an intense rainbow in the classroom, use an overhead projector. On the flat table of the projector, position two large books so that all the light is blocked except a narrow slit in the middle. This slit of light should shine toward the bottom of the projecting lens. Tape the diffraction grating over the lens where the image exits toward the screen or the wall. To fine-tune the width and position of the rainbow, adjust the width of the light slit by moving the books together or apart. You may need to angle the projector slightly to get the image to appear straight ahead on a screen.

The Project ASTRO activities handbook, *The Universe at Your Fingertips*, describes another method for making a bright rainbow in a classroom: Put a slide with a narrow slit in a slide projector, focus to a white vertical line, and position a diffraction grating over the lens.

Activity #1

1. The question: In what order will the colors in the rainbow (or visible spectrum) appear?
2. For the students: Make a hypothesis. What colors will appear and in what order? (redorangeyellowgreenblueindigoviolet)
3. Create the rainbow. Younger students can draw the rainbow and make up a mnemonic for remembering the order of the colors (such as, ROY G. BIV).
4. Check the results against the hypothesis.

Activity #2

1. The question: What colors of the rainbow will be visible with the various filters?
2. For the students: Make a hypothesis.
3. Create a rainbow on the screen or wall. Look at the rainbow through the filters. Filter sheets can be positioned in front of the diffraction grating, or students can look through their individual filters at the rainbow. Which colors can be seen through each filter? Which filters are truest, letting through the fewest number of wavelengths?
4. Check the results against the hypothesis.

For older students

Have students measure the position of the different colors on the screen. A good way to do this is to tape a ruler onto the wall or screen so that it crosses the colors of the rainbow.

- Are all color bands the same thickness?
- Now, check the positions of the colors by looking at them through the color filters. If the filter were merely coloring the light, wouldn't it change the blue light into red light? Instead, the blue light is clearly blocked out.

Why do we get so many different wavelengths of light from the Sun? Why does sunlight seem nearly white, rather than a single pure color? The reason is that photons escaping from the Sun are absorbed, re-emitted, and bounced around millions of times. The light that ultimately escapes from the Sun spans an enormous range of energies.

But guess where most of the energy is? In the visible window! So it's no surprise that our eyes see the wavelengths that they do. It may seem annoying that we can only see light from one small part of the spectrum, but biologists say our brains are busy enough already. They'd be fried if had to sort out all those other wavelengths.

Many students think of invisible light as a different phenomenon from visible light.
It isn't; the various forms of electromagnetic radiation differ only in wavelength.
Our eyes are insensitive to other wavelengths because of evolution.