# Cup Filter Demo

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## Overview

We are often amazed by naturally occurring phenomena. One of the most striking examples is the rainbow. Do you know why rainbows happen? Here you will learn the physics behind the rainbow formation, and extend your understanding with rainbow subtraction.

## Theory

The range of colors (from violet to red) that appear in a rainbow is called the visible spectrum. So why do we see such a spectrum? When white light (combination of six colors: violet, blue, green, yellow, orange, red) passes through a prism or diffraction grating, all six colors bend at different angles depending on their wavelengths. Thus, light of each color spreads out in slightly different directions, creating a spectrum. In the case of the rainbow, water droplets in the air act as prisms. So why do we see a spectrum in this experiment? The lenses of the rainbow glasses you wear during the experiment are diffraction gratings: they contain a series of very fine lines that bend different wavelengths of light to different angles, just like prisms do. A white light from the incandescent light bulb, viewed through rainbow glasses, reaches the viewer's eye through glasses after all its component colors have been bent to different wavelengths. The visible spectra you see here are called continuous spectra. As the solid tungsten filament of an incandescent bulb is heated, the filament gives off white light containing the complete visible spectrum. What happens when you place different colored cup filters over the light bulb? When light interacts with matter, then the matter absorbs light of specific wavelengths (colors) in the visible range. When some of the colors are absorbed in the continuous spectra, we do not see those colors in the spectra. The places where those colors would be located appear black; spectra containing these dark lines are called absorption spectra.

**Necessary materials:**

- insulated cups with food coloring solution in walls
- long-filament incandescent bulb
- dimmer-equipped bulb base
- rainbow glasses (1 pair per student)

## Doing the activity

1. First, have your students put on their rainbow glasses and look around. What do they notice? Have they seen this type of phenomenon before? Under what circumstances? Use their prior knowledge as a springboard to briefly explain how the rainbow glasses work.
2. Turn on the long-filament bulb, and adjust its brightness to a comfortable level using the dimmer. Ask your students to carefully observe the spectra from this bulb. What colors are present? Are there any "breaks" in the spectra? (These are continuous spectra.)
3. Now, have your students pick a cup filter to try first. Ask them to predict what will happen when you put the cup over the light. Carefully hold the cup in place over the light (do not rest the cup on top of the bulb; this may melt the cup). What happened to the spectra? (The cup filter will "knock out" a certain color in the spectra, leaving a dark line in its place -- this is an absorption spectrum.)
4. Repeat step 3 with the remaining cup filters. What patterns do students notice? Is there a connection between the color the cup appears to be and what it does to the spectra?

## Summing up

Different lights emit different kinds of spectra. Different kinds of matter, like the atmosphere on Earth or the Sun will absorb light, and leave a unique absorption spectra. This is how scientist determine what is in the atmospheres on planets and stars.

## For more information

Little Shop of Physics: https://www.lsop.colostate.edu

Colorado State University College of Natural Sciences: https://www.natsci.colostate.edu