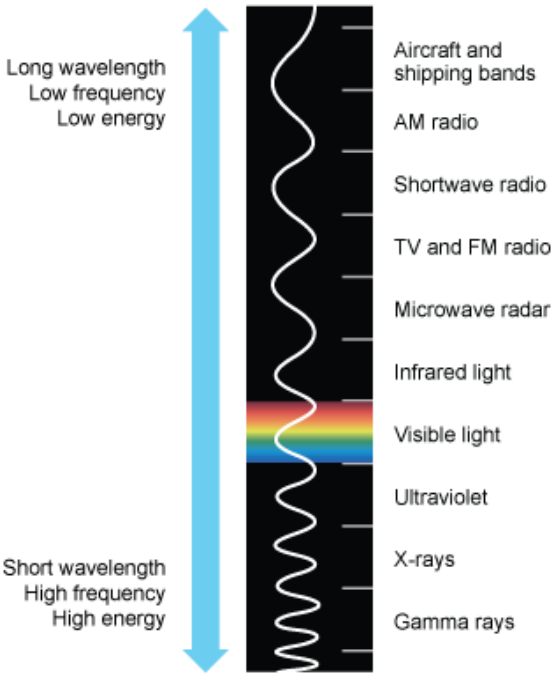
# Catch a Wave: Make your own Spectrometer

**Objective:**
As every element gives off a different spectrum of light when heated, you will build a spectrometer to compare the spectra of several sources of light.

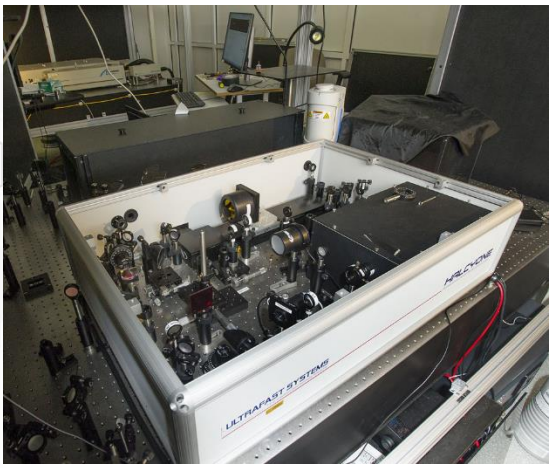
**Vocabulary:**
spectrum, electromagnetic radiation, diffraction grating, photodetector, wavelength, electromagnetic spectrum, element

**Background:**
When you look at a rainbow you're seeing the different colors of light from the sun separated out into the visible spectrum. Each color is a different wavelength of light. All light is composed of waves of electromagnetic radiation. A spectrometer is a tool that separates white light into a spectrum of colors. Isaac Newton used a similar apparatus in his work on the visible spectrum of light. Newton originally divided the spectrum into six named colors: red, orange, yellow, green, blue and violet. He later added indigo as the seventh color since he believed that seven was a perfect number.




http://www.bbc.co.uk/schools/gcsebitesize/science/images/addgateway_elecspec.gif

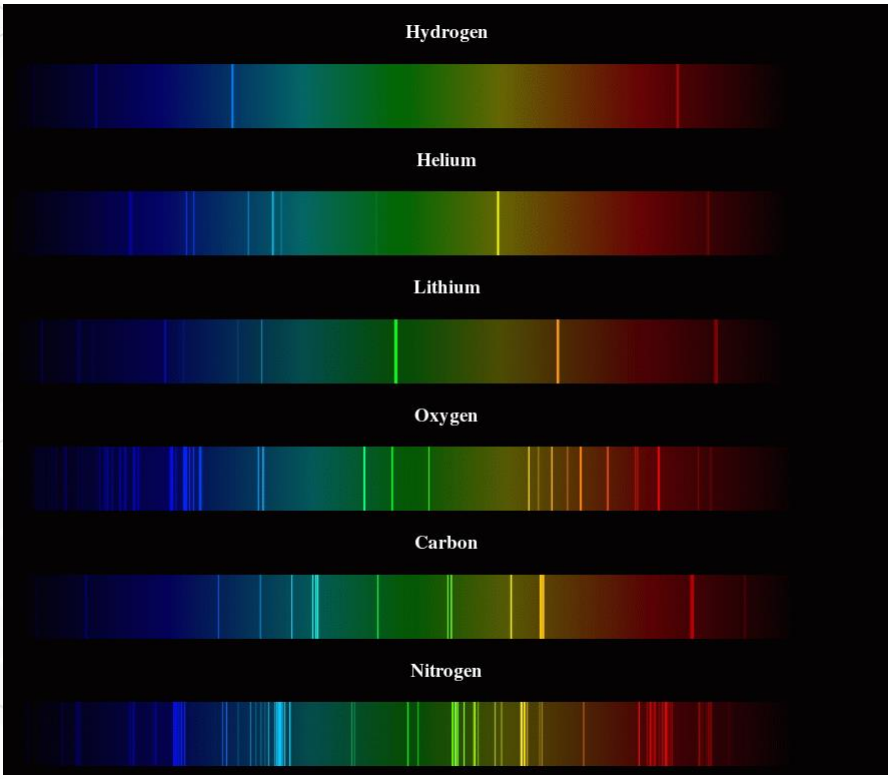
A spectrometer is a measuring device that collects light waves. Every element gives off a different pattern, or "fingerprint," called spectrum lines. For example, the element neon emits light primarily in the longer red, orange and yellow wavelengths and not much in the shorter blue or violet wavelengths. No two types of elements produce exactly the same set of lines, just as no two people have exactly the same fingerprints.



Halcyone Fluorescence Up-conversion Spectrometer, Image credit: CFN
This spectrometer is used at the Center for Functional Nanomaterials and measures spectra in the visible and near infrared spectrum.

Spectroscopy is a science that uses these light waves to determine the elemental composition of a material. When objects are heated they emit visible light at a given point or points on the electromagnetic spectrum. Spectrometers split the incoming light wave into its component colors. Using this information, they can determine the material's composition.

A spectrometer is a simple assembly of a small slit to allow the light in, a diffraction grating to refract, or bend, the light and a photodetector, such as your eye. The slit allows a beam of light into the interior of the spectrometer, where the light passes through the diffraction grating. The grating splits the light into a spectrum of its component colors, similar to a prism.



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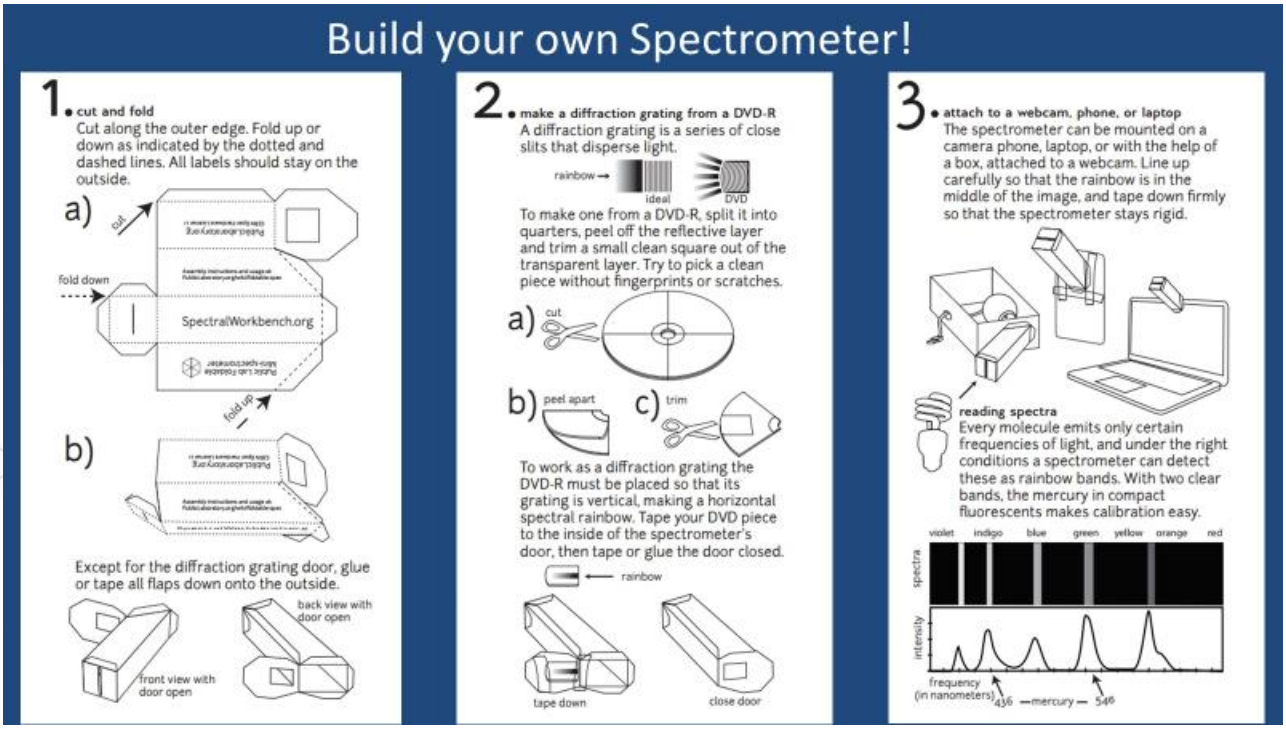
**Make your own Spectrometer**

**Materials:**

- Public Labs Template PDF: foldable-2.0.7.pdf or SVG: foldable-2.0.7.svg
- Scissors
- DVD-R
- Dark cardstock
- tape - clear, black tape, anything that sticks well to paper
- narrow slit, follow these steps to make one out of paper

**Procedure:**

Step 1: Build the spectrometer. Use the Public Lab template and instructions. Click here for a printable pattern and directions: https://publiclab.org/notes/warren/11-30-2017/build-a-papercraft-spectrometer-for-your-phone-version-2-0




Step 2: Once you have your portable spectrometer assembled, put your eye up to the viewing hole, hold the tube so light enters through the slit. You should see different colored bands, which is the light reflected off the DVD-R. You may need to adjust the angle to see a “rainbow” or spectrum.

Step 3: Now try looking at different sources of lights such as LED, fluorescent, incandescent, candle flame, flashlight, car headlights, or cloudy sky. **[SAFETY: Never point the spectrometer at the sun].** Make note of what you observe. Are there differences? Fluorescent lights produces bright lines that are the spectrum of mercury gas inside the tube. Incandescent lights make a continuous spectrum from the light produced by heating the metal filament.

Observations:

Compare and share your observations with one person of your choosing!

Step 4: (CHALLENGE) You can calibrate, upload and contribute to the open-source project at https://publiclab.org/wiki/spectrometer

**Light as a Discovery Tool:** Spectroscopes are used in astronomy to study the light from stars and other celestial objects, and in chemistry to detect the presence of traces of various elements in samples that are too small to analyze by other means.

Brookhaven National Lab conducts scientific research using photons—particles of light—to probe the structure and makeup of materials. The National Synchrotron Light Source II (NSLS-II) uses electrons accelerated along a high-tech ring at nearly the speed of light to create beams of light in the x-ray, ultraviolet, and infrared wavelengths, resulting in a kind of giant microscope. Learn more by visiting: https://www.bnl.gov/science/photon-science.php

**Science News Highlights:**
Beating the Heat in the Living Wings of Butterflies

https://www.bnl.gov/newsroom/news.php?a=217044

Illumination: Revealing the Secret Chemistry of Oil Paintings. The spectroscopy beamline at NSLS II helped to identify different elements in oil paintings from the Metropolitan Museum of Art. https://www.bnl.gov/newsroom/news.php?a=213129

Pigments in Oil Paintings Linked to Artwork Degradation.

https://www.bnl.gov/newsroom/news.php?a=212627

Plant Roots Police Toxic Pollutants. Using the spectroscopy beamline to identify toxic elements that were taken up by plant roots.

https://www.bnl.gov/newsroom/news.php?a=212954

Peering into How Rechargeable Lithium Ion Batteries Function

https://www.bnl.gov/cfn/research/highlights/news.php?a=25595

**This lesson is adapted from Public Lab and the Exploratorium.**