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Educational Innovations Inc.®

Double Axis Diffraction Grating / Prism Glasses

PG-1, PG-2, PG-3

HOW A DIFFRACTION GRATING WORKS

(Without Equations)

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Optical Sciences Center
The University of Arizona

When we begin learning about light we usually start by talking about the colors of the spectrum and the fact that white light can be broken up, or dispersed into a spectrum of colors. To disperse light into its spectrum Sir Isaac Newton used a prism. However, in recent years the diffraction grating has replaced the prism for this purpose because it is easier, more effective and less expensive.

Diffraction gratings are not new. They've been the basis of spectroscopic instruments for a long time, but these instruments are not necessary for many learning purposes. You can see exciting and detailed spectra simply by holding a diffraction grating up to your eye and looking through it at a light source in a dark place.

Eventually, the question arises, "How does a diffraction grating work?" It's not easy to find an answer to this question that doesn't get mathematical, yet explains the principle in a satisfying way. The following attempts to do that.

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Light waves are similar to water waves in many respects. Let's start with the familiar situation of water wave ripples due to a dropped pebble. Fig. 1 shows how their spread can be understood by considering each point along a wave, or a wave front, to be the source of a new wavelet, each source having the same phase.

WAVES IN A POND

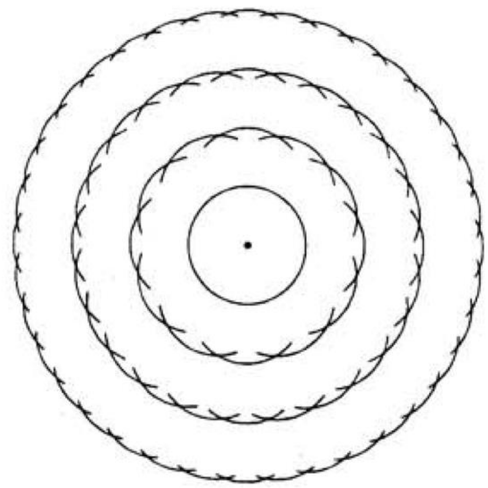


Fig. 1

Now let's apply this model to a wave that encounters an obstruction such as a single narrow slit. Fig. 2 shows how the wave spreads. The difference between successive peaks or valleys is called the wavelength, λ.

ONE SLIT

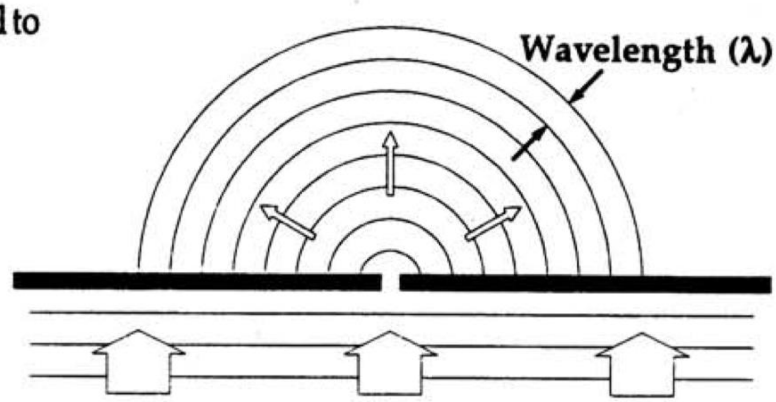


Fig. 2

Now let's increase the number of narrow slits, equally spaced as shown in Fig. 3. This is called a diffraction grating.

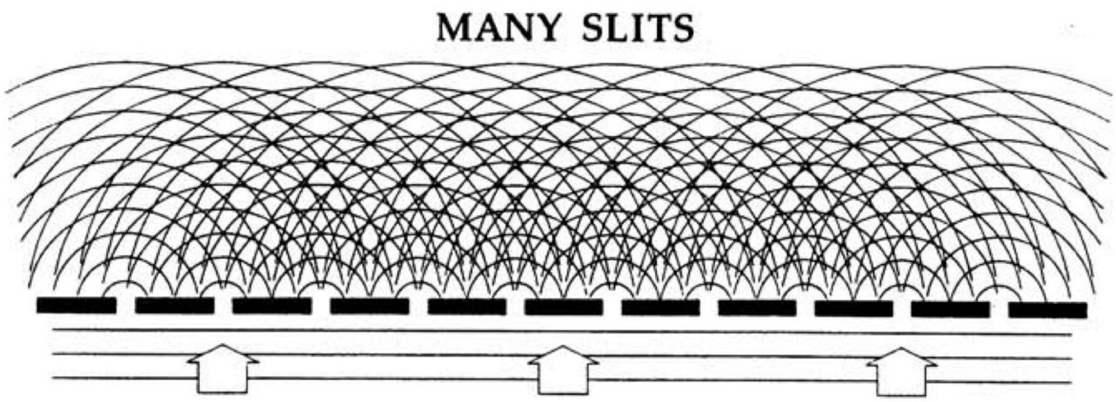


Fig. 3

When a light wave encounters a diffraction grating, the light spreads as if it originated from many point sources, each in phase with one another. Just as shown in Fig. 2, each wave spreads out in a circle, but now there are centers at each slit as shown in Fig. 3. If one wavelet's peak lies on another wavelet's valley, the result is neither peak nor valley, but rather cancellation. However, if one wavelet's peak lies on another wavelet's peak, they add constructively, making a wave twice as high.

There are special directions where cancellation is avoided and the wavelets add constructively. One such direction is indicated in Fig. 4.

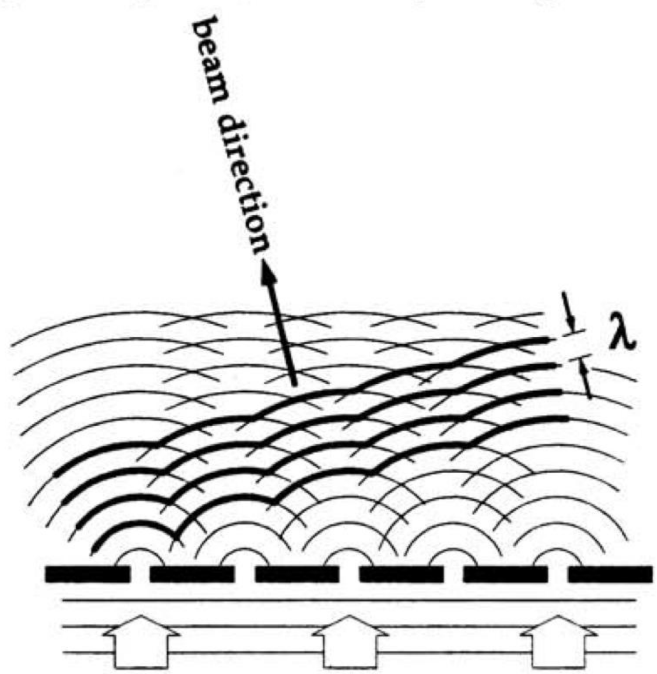


Fig. 4

This direction is different for different colors because different colors have different wavelengths. For example, since the wavelength of red light is longer than the wavelength of blue light, a red beam is diffracted or bent further than a blue beam when it passes through the diffraction grating (see Fig. 5).

RED LIGHT BENDS MORE THAN BLUE LIGHT

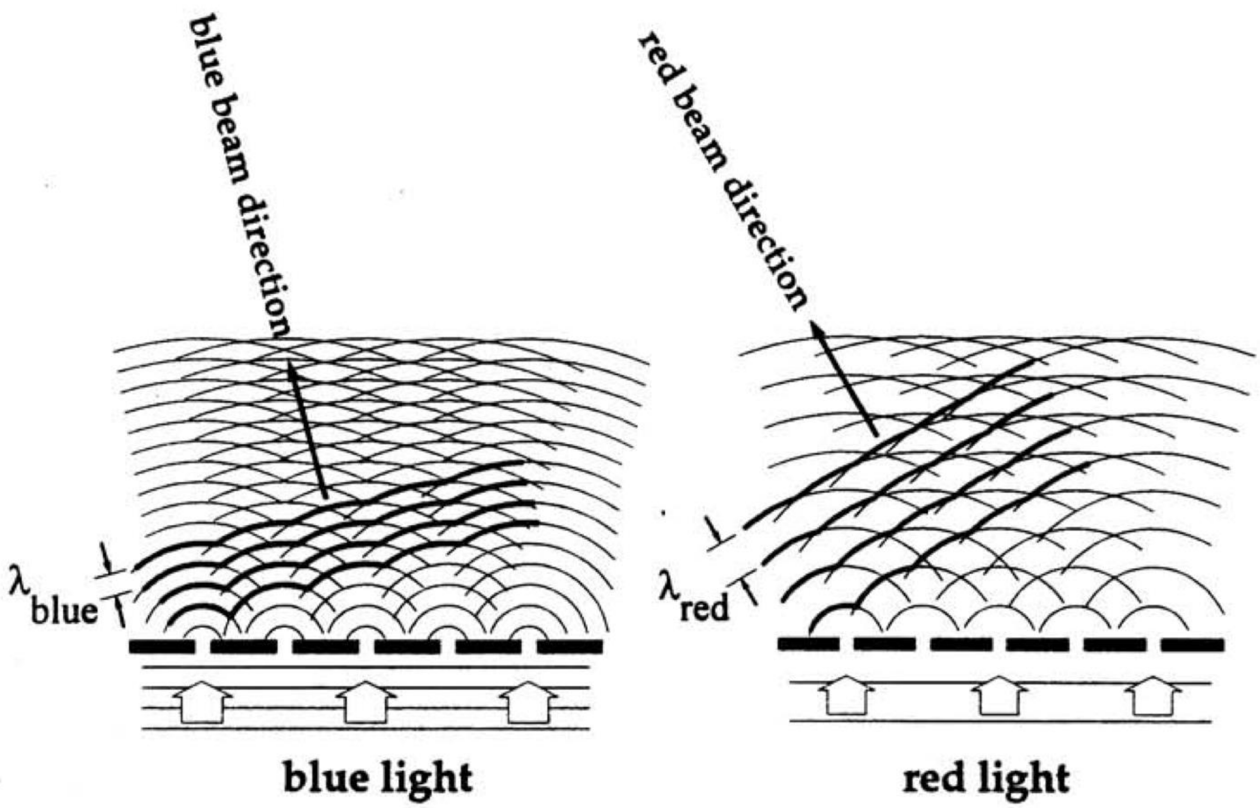
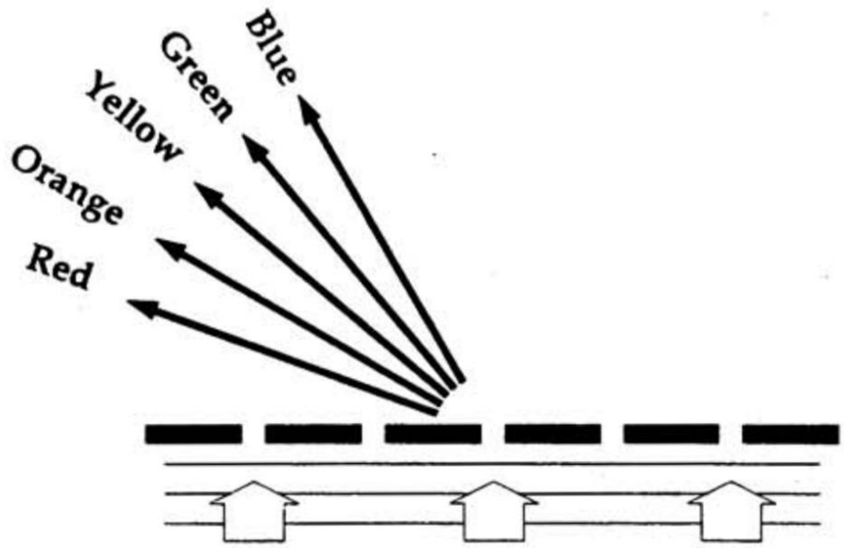


Fig. 5

This is how a diffraction grating breaks up the colors of white light. White light has many colors. Between red and blue are other colors, like orange, yellow and green, whose wavelengths are intermediate between those of red and blue light.

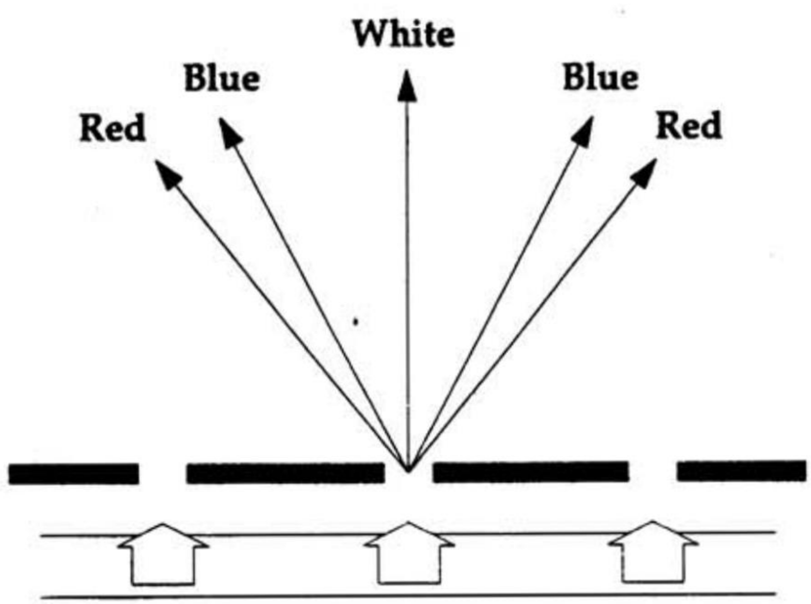
Putting this all together, we can see how a beam of white light, which contains all the colors, gets bent, or diffracted into a spectrum of colors.



WHITE LIGHT (ALL COLORS)

Actually, there are other directions where wavelets add constructively. These are shown below.

SPECTRA ON BOTH SIDES



NGSS Correlations

Our Double Axis Diffraction Grating products and these lesson ideas will support your students' understanding of these Next Generation Science Standards (NGSS):

Elementary

1-PS4-2
Students can conduct investigations showing evidence of illumination from an external source such as the Sun.

1-PS4-3
Students can use this tool to conduct an investigation of how different materials affect the path of a beam of light.

Middle School

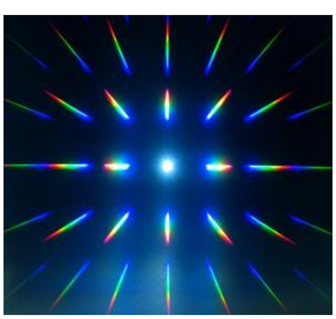
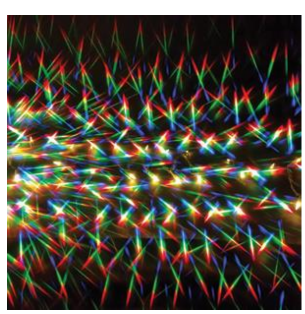
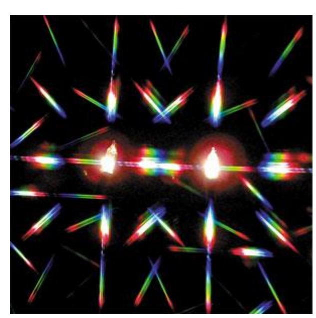
MS-PS4-2
Students can use this tool to develop and use a model to describe how waves are reflected, absorbed, or transmitted through various materials.

High School

HS-PS4-1
Students can use lenses to conduct investigations and use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

HS-PS4-5
Students can use the Prism Glasses to conduct investigations about technological devices use the principles of wave behavior and wave interactions with matter to transmit.



Take Your Lesson Further

As science teachers ourselves, we know how much effort goes into preparing lessons.
For us, "*Teachers Serving Teachers*" isn't just a slogan—it's our promise to you!

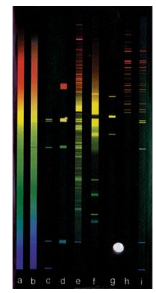
Please visit our website for more lesson ideas:

TeacherSource.com/lessons

Check our blog for classroom-tested teaching plans on dozens of topics:

http://blog.TeacherSource.com

To extend your lesson, consider these Educational Innovations products:



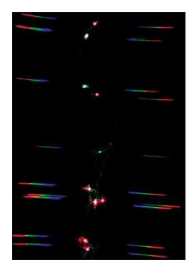
Night Spectra Quest Spectrum ID Card (PG-5)

Using this card with our Prism Glasses, Rainbow Viewers or with the small diffraction grating view port on the card, students can identify the source of a wide variety of close and distant night lights. The full-color card shows line spectra from nine different light sources including fluorescent, incandescent, mercury vapor, sodium vapor, neon, etc. Comes with complete instructions and a description of how a diffraction grating works.

Hand-Held Spectroscope (SPC-100)

Reveal the hidden nature of color and visible light with this durably constructed, economical spectroscope. Measure the wavelengths of visible light from 4000 to 7000 Angstroms with the precision of +/- 50 Angstroms using the built-in scale. Instructions include the history of light theory, diffraction gratings, and suggestions for numerous experiments.

Single Axis Diffraction Grating (PG-400)



This has been one of our most requested products. Although we love our double axis diffraction gratings, sometimes it is easier to use a single axis diffraction grating for measuring emission spectra in the classroom laboratory. Educational Innovations is happy to offer this superior grade single axis grating. It gives brilliant spectra with fluorescent lights, flame tests, gas discharge tubes, or even holiday lights!

Pocket Spectroscope (ROY-100)

This is the best adjustable slit spectroscope we have seen. By varying the amount of light passing into the prism, this portable spectroscope is able to resolve even very close or dim spectral lines. This makes identifying a light source easier and more accurate. Use for examining the spectral composition of white light, sodium vapor or mercury vapor street lamps, LED's, neon signs, and more. Similar to Oliver Sacks' pocket spectroscope which he used as a youth and is described in Uncle Tungsten. The metal spectroscope is 20 mm in diameter, 130 mm long when fully extended and has an adjustable light aperture at one end. Light passes through the slit, through a prism and is observed as a spectrum at the other end. Each quality spectroscope comes in its own beautiful wooden box.