HOW A DIFFRACTION GRATING WORKS
(Without Equations)

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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WAVES IN A POND

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.

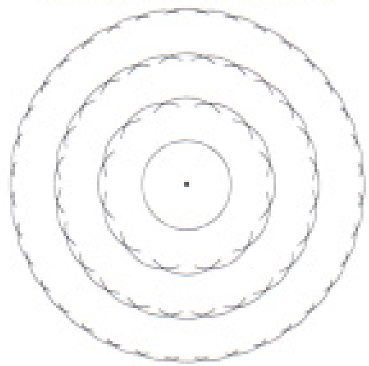


Fig. 1

ONE SLIT

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.

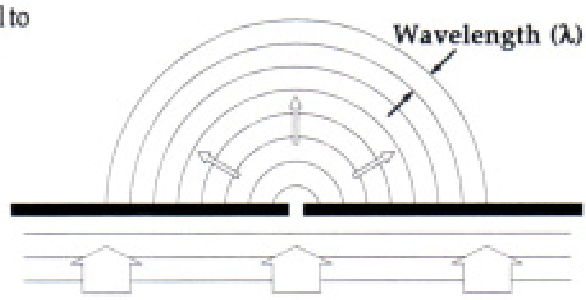


Fig. 2

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

MANY SLITS

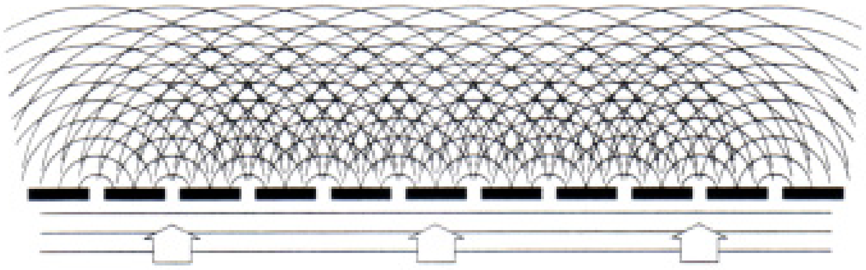


Fig. 3

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.

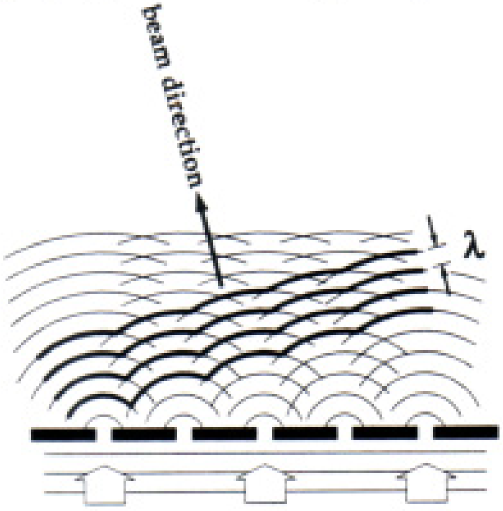


Fig. 4

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

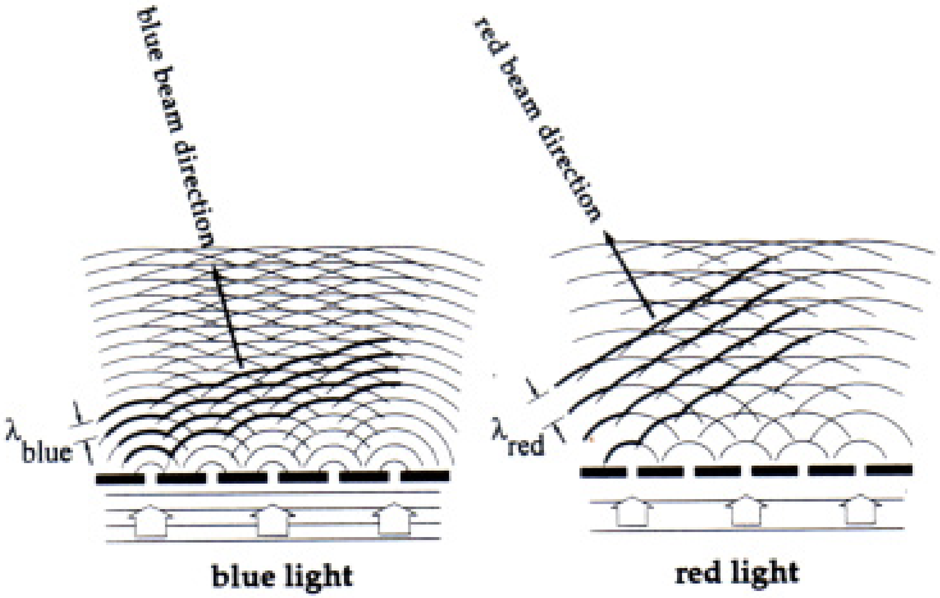
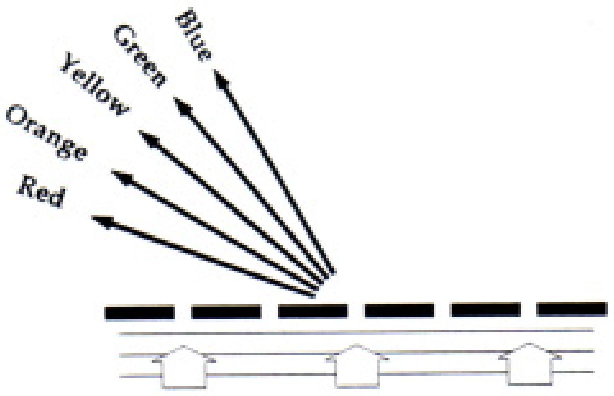


Fig. 5

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.

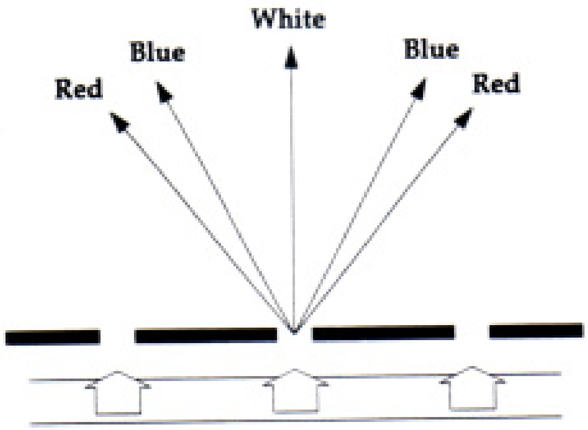
Putting this all together, we can see how a beam of white light, which contains all the colors, gets bent, or diffracted into a spectrum of colors.



WHITE LIGHT (ALL COLORS)

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

SPECTRA ON BOTH SIDES



Experiments with Diffraction Gratings

Two sets of experiments are available

1. NIGHT SPECTRA QUEST is a chart that shows the color spectra of common night lights, identifies each spectrum, and includes a diffraction grating through which you can see them.

   An accompanying booklet presents background information and practical suggestions about using NIGHT SPECTRA QUEST. You easily can survey the night light spectra while riding around after dark, holding NIGHT SPECTRA QUEST up to your eye, with someone else driving.

2. Advanced Experiments with Diffraction Gratings
   - How A Diffraction Grating Works (with equations)
   - Measuring the Grating Constant, d
   - Resolving Power
     - ◇ Theoretical (what you *should* be able to resolve)
     - ◇ Experimental (what you *actually* can resolve)
   - Looking at the Sun's Fraunhofer Absorption Spectrum
     - ◇ How to see the spectrum with just a grating
     - ◇ Spectrum chart showing which lines are of terrestrial vs. solar origin.

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