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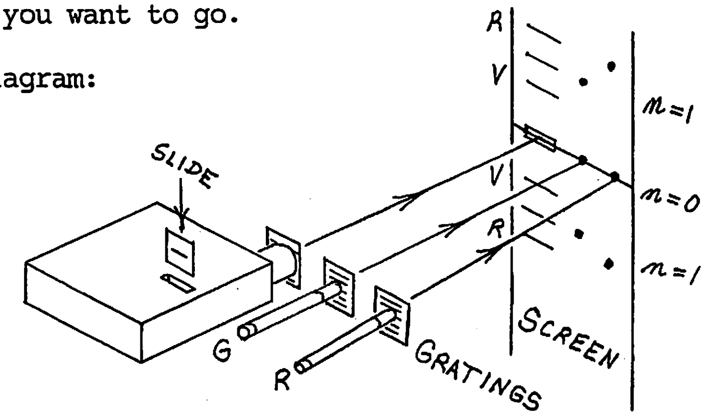
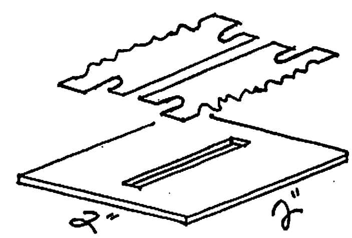
Dispersion - spectra via diffraction and interference. If you want to dazzle your audience with an exceptional display of the visible spectrum (the colors), this rather simple set up will do it. Kodak designed a white-light system, their Carousel slide projector, to show their quality slide film at its best. Make up a simple, single-slit slide, add an excellent holographic diffraction grating, and locate a screen (white wall?). The set up is illustrated below. For even more interest, you may wish to add green and red laser pointers to the show. What is happening here to cause this beautiful display? It all goes back to Young's double slit experiment, back to diffraction and interference, to the fact that a diffraction grating is many double slits, and to some simple geometry (similar triangles). And we can go from qualitative to quantitative with it. You decide how far you want to go.

Diagram:



single slit slide:



Materials: Kodak Carousel slide projector, single slit slide, holographic diffraction grating (750 lines/mm)*, screen (vertical?), laser pointers: green (532 nm) and red (635 nm), extra grating(s)

* #33-0980 Holographic diffraction grating, Arbor Scientific, Ann Arbor, MI 1(800)367-6695

Preparation: (a) To make the single slit slide (above right), cut out a 2" x 2" heavy cardboard (posterboard) square. Cut out a narrow, 1¼" x 1/8", single slit in the center of the square. Take a double-edged razor blade, carefully snap it in two or use the modern single-edged blades (2) and tape each cutting edge, facing each other and 2.5 mm apart, over the cardboard slit.

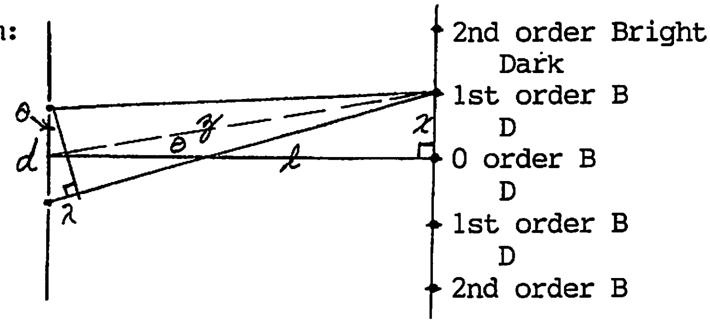
(b) To make a vertical screen, take one piece of 22" x 28", white, posterboard and cut it in half (11" wide). Glue the two long pieces end to end with a 3/8" overlap. The final screen will be 11" x 55½". Hang it on the wall or on a stand.

(c) Arrange the set up as above. With the slit slide in the projector and the grating in front of the lens, adjust the focus of the white-light slit on the screen at $n = 0$; it should be sharp (clear edges). The spectrum in $n = 1$ should now be at its best. To extend the life of the projector's bulb, use it sparingly, and cool it thoroughly before moving the projector. A hot filament is fragile and breaks easily due to vibration.

(d) For the colors, the darker the room, the better. The laser pointers are not as dependent because of their high intensity.

Explanation: As with Young's experiment, light passing through the parallel slits, lines, or scratches of the grating diffracts and interferes along regions in space until it hits the screen. Regions of in-phase, constructive interference will be bright and out-of-phase, destructive, dark. Using the rule of similar triangles that the sides of two triangles are proportional if their sides are parallel and/or perpendicular to each other, the equation for the minute wavelength (λ) of the light involved can be derived and the value of λ determined for any color.

Diagram:



λ = wavelength
d = dist. between slits
x = dist. between 0 and 1st orders
z = dist. from center of barrier to 1st order on screen
l = dist. from slits to screen

$$\frac{\lambda}{d} = \frac{x}{z}$$

$$\lambda = \frac{d\,x}{z}$$

$$z = \sqrt{x^2 + l^2}$$

You may not use l in place of z because of the high quality of this grating. θ is much too large (the dispersion too great). Of course, d is the reciprocal of 750 slits/mm or equal to 1/750 mm or .00133 mm between slits. x and z (l?) may be measured with a meter stick or metric tape measure. Don't expect a useful 2nd bright order with this grating; too much distortion.

Presentation: Once you have set up this demo and have seen the results, you can decide the order of presentation. Lasers first or projector first? Regardless, one will reenforce the other. If you decide to go on to find the red and green λ's of the lasers, you can show, via the equation, how easy it is to find the λ's of the other colors in the full spectrum. This is truly a memorable demo with some simple math and good physics in it. It just goes to show that physics can be beautiful!

A special note and warning: Fifty years ago, Kodak developed a quality slide projector, the Carousel, for the general public. It had a quality lens system, cooling system, and light source, all beneficial to physics teaching as a source of intense, controlable white light. Over the years, the uses in physics teaching for the Carousel projector have grown, to the point that some of the best demonstrations on the topic of light depend on it. Still there are physics teachers who don't have them and can't perform these important demos that would enhance their teaching. And time is running out. The new electronic technology is relegating the Carousel projector to storage, if not disposal. What a shame! And what is to replace it as an economical white light source for physics teaching? If these projectors and their bulbs are being trashed, grab them! They were a "gift" 50 years ago and are a treasure today! Ask your students if they have any at home that they would like to donate to the physics department for instructional use. Find a way to save them before they are destroyed! Act now! The Kodak Carousel projector "center" is still Rochester, NY where used camera/projector stores still exist and where they and private individuals (retired Kodak service people) have parts and make repairs. They are also a source for bulbs. Most advertise in the yellow pages and probably on line. I own two projectors with several spare bulbs for my use. I recommend the same for you. The value of these projectors will go up, not down, with fewer available. Again, don't delay; act now!