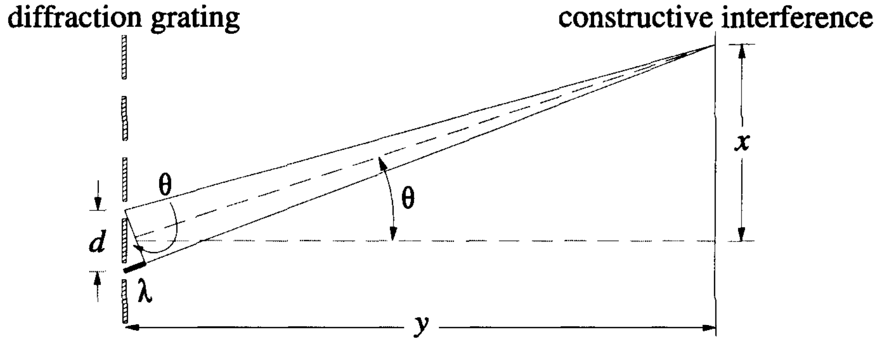
Name **Section #**

Diffraction, Interference, and Color

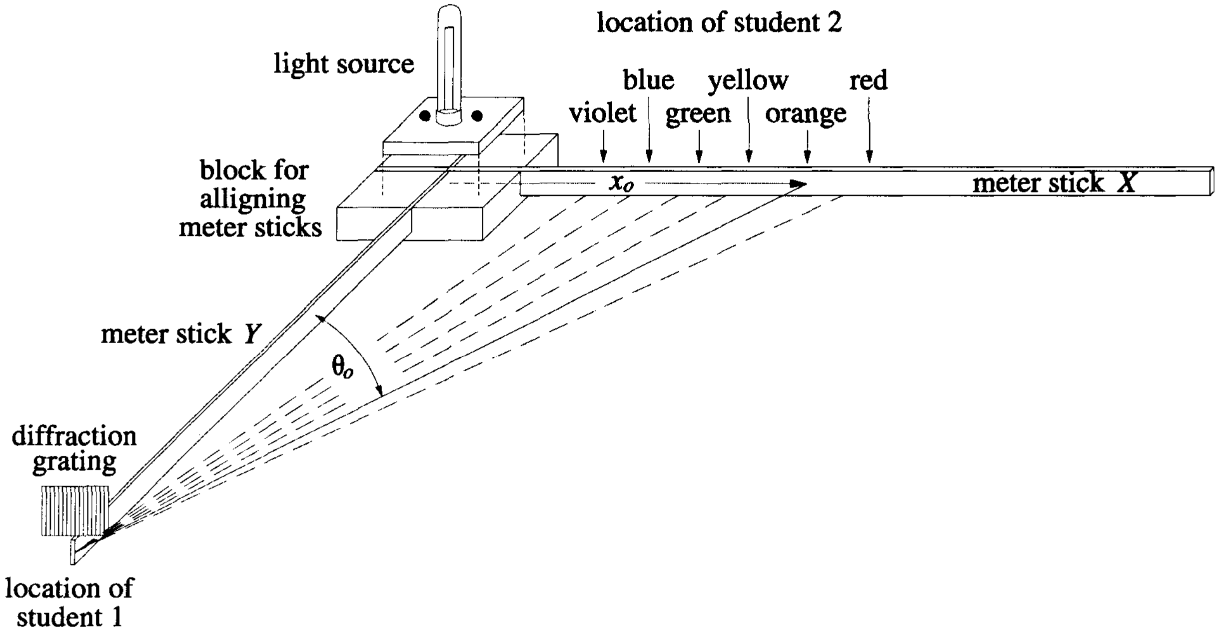
Purpose

You will use a diffraction grating to measure the wavelength of the six principal colors in the visible spectrum, namely: red, orange, yellow, green, blue, and violet.



Theory

The relationship between λ, the wavelength of a color; d, the distance between the rulings of a diffraction grating; and the angle θ is, $\lambda = d \sin\theta$. You will be using a diffraction grating with 13,400 lines per inch so that the distance d between two adjacent lines or rulings is 7.46×10^{-5} inches, which in SI units is, $d = 1.90 \times 10^{-6}$ m. To obtain $\sin\theta$ for each color, note that $\tan\theta = \frac{x}{y}$. Solve for $\tan\theta$, find its inverse (this will give you θ), then press the sine function to get $\sin\theta$.



Procedure

Use the block to set up two meter sticks at right angles to each other as shown in the above diagram. Place the light source on top of the block where the meter sticks intersect. One student, viewing the light source through the diffraction grating located 1.0 m away, will see all the colors of the spectrum spread out along the meter stick labeled X. A second student, standing behind meter stick X, should use a marker such as a pencil to locate each color seen by the first student. The second student will not see the colors, his function is to move the marker along meter stick X in accordance with the instructions issued by the first student.

The distance, in centimeters, from the light source to a particular color should be entered under the column headed x in the data table. Since the diffraction grating will always be situated one meter away from the light source, all entries in the column headed y will be 100 cm. Calculate $\tan\theta$, and from that, $\sin\theta$, as outlined in the theory section. Finally, determine the wavelength λ of the color from the relationship: $\lambda = d\sin\theta$.

Record the data for every one of the six colors in the table. Be certain that the meter sticks X and Y are perpendicular to each other. You will observe that each color spreads over a range and then merges into the next color. Let your x–measurement be from the center of the light source to the center of the perceived color. To enable the student with the diffraction grating to see the colors clearly, a third student should hold up a dark background (such as a black coat or book bag) behind meter stick X. Such a strategy will serve to block light coming from other lab stations.

Color	x (cm)	y (cm)	$\tan\theta \left(=\frac{x}{y}\right)$	$\sin\theta$	λ $(=d\sin\theta)$ (m)
violet		100			
blue		100			
green		100			
yellow		100			
orange		100			
red		100			

The *Physics Reference Table* lists the range of wavelengths for each of the colors. You will find the center of each range in the table under the column headed "Accepted Value." Compare these with your experimental values.

Color	Accepted Value	Experimental Value	% Difference
violet	4.3×10^{-7} m		
blue	4.8×10^{-7} m		
green	5.3×10^{-7} m		
yellow	5.8×10^{-7} m		
orange	6.0×10^{-7} m		
red	6.5×10^{-7} m		

Questions

What factors do you think were responsible for the differences between your experimental values for each of the colors and the accepted values?

How would your measurement of x for each of the colors in Table I change if you had used a diffraction grating with double the number of lines per inch? Explain.

Which color is bent most by the diffraction grating? Which color is bent least?

Which color is bent most by a glass prism? Which color is bent least? If your answer is different from the answer given in the previous question, explain why.

Which part of the electromagnetic spectrum would you expect to be diffracted through a greater angle, x-rays or radio waves? Justify your answer.

Supplementary Activity

Replace the light source with the hydrogen gas tube in order to determine the wavelengths of the four visible lines in the Balmer Series. Please exercise due care as these tubes operate across a potential difference of 10,000 volts. *Do not replace a gas tube or touch any exposed metal surface of the apparatus while the power is on.* Since the light from the gas is not very bright, you may have to view from a distance $y < 100$ cm . Use the same procedure as previously to fill in the table below. You will probably be unable to discern H_δ since it lies at the extreme edge of visibility.

The Hydrogen Spectrum: The Four Visible Lines of the Balmer Series					
Color	x (cm)	y (cm)	$\tan\theta \left(=\frac{x}{y}\right)$	$\sin\theta$	λ ($= d\sin\theta$) (m)
H_α, red					
H_β, blue-green					
H_γ, violet I					
H_δ, violet II					

If you have additional time, examine the spectra for helium, mercury, neon (many colors other than red, quite interesting!), and air.