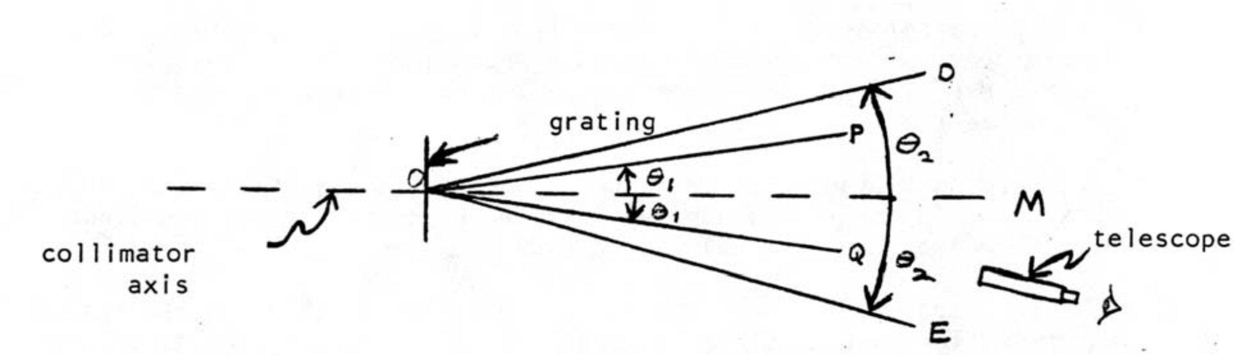
DIFFRACTION GRATING – SIMPLE SPECTROMETER

OBJECT

To measure the wave length of light with a diffraction grating.

APPARATUS

Force table spectrometer, diffraction grating, known light source, spirit level.



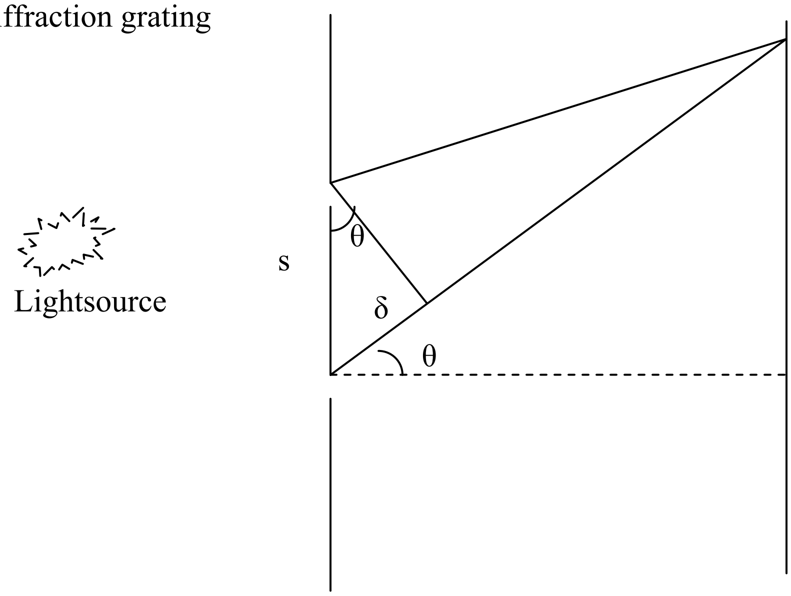
THEORY

The wave length of light, λ, can be measured with a diffraction grating of the transmission type using:

$$\delta = n\lambda = S \sin \theta_n \qquad (1)$$

where S is the distance between the rulings of the grating, θ is the diffraction angle, and n is the order number. n can have values of 0, 1, 2, 3,….. these are the orders of the spectra produced n = 0 corresponds to the direct ray (all colors mixed), n = 1 corresponds to the first time the colors appear (separated), n = 2 corresponds to the second time the separated colors appear, etc. Constructive interference occurs when the difference in path length (δ) between the two light rays is equal to a multiple of a whole wavelength. See the diffraction grating diagram below. This is the way the colors are spread apart, the different wavelengths will make for a different position for constructive interference in the viewing telescope.

Diffraction grating



PROCEDURE:

1. The apparatus needs no adjustments. This has already been done.

2. Clamp the grating in place on the spectrometer table so that it is perpendicular to the collimator axis as indicated in the diagram. Handle the grating by the edges only.

3. Swing the telescope around so that it is in line with the direct ray OM. Read the degrees and vernier scale and record the reading.

4. Slowly move the telescope away from the direct ray until a spectral line appears. Record the angle reading. The difference between this reading and the reading for the direct ray is the angle θ_1.

5. Slowly move the telescope to the other side of the direct ray until the same spectral line appears. Record the angle reading. The difference between this reading and the reading for the direct ray is another value for θ_1.

6. Compute the mean value for θ_1.

7. Slowly move the telescope farther from the direct ray until another spectral line appears. Repeat the procedures of 4), 5), and 6).

8. Repeat 4), 5), and 6) for several spectral lines.

9. Move the telescope still farther from the direct ray until a second set of these spectral lines is encountered. This set of lines is the second order diffraction spectrum. Repeat the procedures of 4) and 5) and compute the mean value of θ_2.

10. Determine S, the distance in cm between two consecutive lines on the grating. S in cm is obtained by dividing the number of grating lines per inch (marked on the grating) into 2.540.

11. Use the data of steps 6 thru 10 in equation (1) to calculate the wavelength, λ, for each spectral line observed. (In step 9, the lines are second order lines and $n = 2$ for each of these.) Find the mean value of λ for each order and each color (wave length).

12. Calculate the percent error in the measurements of λ's with respect to the values provided by the laboratory instructor.

WAVELENGTHS OF PRINCIPAL LINES OF EMISSION SPECTRA

Helium		Mercury	
Color (x10 $^{-5}$ cm)	Wavelength (x10 $^{-5}$ cm)	Color	Wavelength
Red	7.065	Red	6.234
Red	6.678	Red	6.152
Yellow	5.876	Yellow	5.791
Green	5.016	Yellow	5.770
Blue-Green	4.922	Green	5.461
Blue	4.713	Blue-Green	4.916
Blue	4.471	Blue	4.358
Blue	4.387	Violet	4.078
Violet	4.121	Violet	4.046
Violet	4.026		

Diffraction Grating
Approximately
15,000 lines – in $^{-1}$