

DISCUSSION:

A plane diffraction grating is a series of slits placed very close together. It uses the same principle as single and double-slit experiments. Light passes through the slits and produces an interference pattern. The slits are narrow and numerous so that the interference fringes are sharp and well spaced, making it easier to use than single or double-slits. By measuring fringe separation, you can calculate the wavelength of the light.

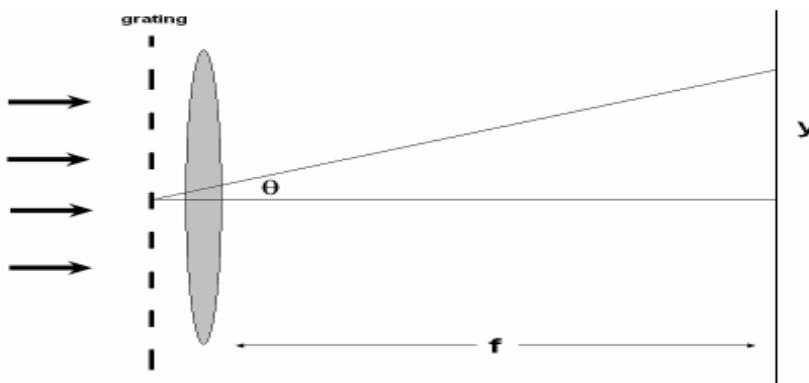
If the focal length of a lens is placed behind the grating and we use the small angle approximation of $\theta = y/f$, the distance y from the lens axis to the m^{th} maximum on the screen is given by

$$y = \frac{m\lambda f}{d}$$

where λ is the wavelength of the incident light and d is the slit separation (which is given).

THE EXPERIMENT:Part I

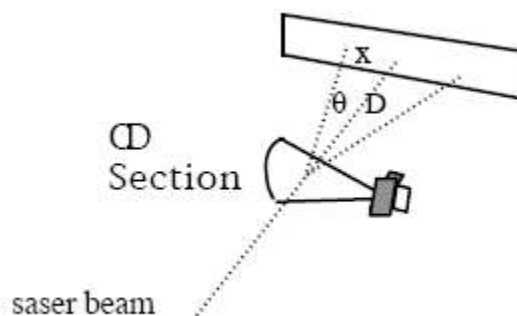
In this experiment you will use a diffraction grating to measure the wavelength of the light produced by a laser pointer. The set up is shown here.



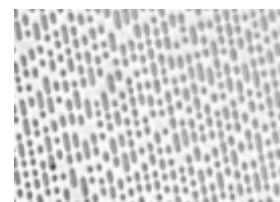
1. Set up the laser on one end of the optical bench so that it is not aimed at another group or student in the classroom. Do not look into the laser.
2. Place the diffraction grating and a lens with a focal length of at least +30mm on opposite sides of the same component carrier. The diffraction grating should be on the same side as the laser.
3. With the beam passing through the grating and the lens, position the viewing screen such that the light is focused. (Hint: what is the focal length of the lens?)
4. Collect all the data necessary to measure the wavelength of the laser and repeat the experiment with 2 more known diffraction gratings.

Part II

Now that you know the wavelength of the laser, you can use that information to calculate the slit-spacing on unknown diffraction gratings.



The data on a CD is stored in a spiral of "pits" as shown in this picture.



Now that you know the wavelength of the laser you can reverse the calculation to measure the spacing of this spiral

Part III

In this experiment you will calculate the width of a human hair. Babinet's Principle states that single slit interference patterns can be shown by blocking the path of light using an obstacle which is close in width to the single-slit.

Single-slit measurements are similar to diffraction grating measurements. The angle θ from the center of the slit to the first minimum m , is given by

$$a \sin \theta = m\lambda$$

where a is the slit width. The angle θ is related to D and y by

$$\tan \theta = \frac{y}{D}$$

5. Tape a short piece of hair (donated by a group member) vertically to the slit mask.
6. Place the card between the laser and the viewing screen, allowing the laser to strike the hair.
7. Observe the interference pattern on the viewing screen and take the necessary measurements.

ANALYSIS

Part I

- Using the data you collected in Part I; take the average of your calculated values and compare it with the both the maximum and minimum wavelengths noted on the laser.
- What is your experimental error?

Part II

- Determine the spacing between the lines in a CD.

The nominal track separation on a CD is 1.6 micrometers, corresponding to about 625 tracks per millimeter. This is in the range of ordinary laboratory diffraction gratings.

- Compare calculated line spacing with the accepted values. What is your experimental error?
- What do you think caused your error?

Part III

- Using the data you collected in Part II; determine the width of a human hair.

The standard accepted value for the width of a human hair is 10^{-4} m on average.

- Compare your calculated hair width with the accepted value. What is your experimental error?
- What do you think cause your error?