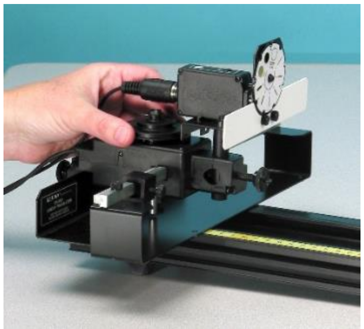
Name: Melissa Chang | Group Members: Noel, Amy, Imaal, Melissa

LAB 20. WAVE OPTICS: DIFFRACTION

AP PHYSICS II



Driving Question | Objective

What proof do we have that light is a wave? How will light behave is traversing through narrow slits?

You will use our PASCO equipment to design an experiment to determine the quantitative relationship between these two variables.

Design and Conduct Your Experiment

It is your group's responsibility to design and conduct an experiment whose data will support your answer to the driving question above.

Materials and Equipment

- Light Sensor
- Rotary Motion Sensor
- Linear Translator
- Single Slit Accessory
- Multiple Slit Accessory
- Aperture Bracket
- Diode Laser
- Optics Bench

Experimental Design Pt. 1 – Double Slits

1. You will be attempting to determine the relationship between the position of two slits and the diffraction pattern formed at a significant distance.
2. Begin by attaching the Viewing Screen and Diode Laser on opposite ends of the Optics Bench with a significant distance of separation. Attach the Multiple Slit Accessory at a location close to the Diode Laser.

3. Begin experimenting with different variables such as slit-to-screen distances and separation of slits and analyze their effects on the diffraction pattern located on the Viewing Screen.
   a. How does the slit-to-screen distance affect the spacing of the diffraction pattern?

When the distance between the screen and the slits increases the spacing in the diffraction pattern is greater. L has a direct relationship with x.

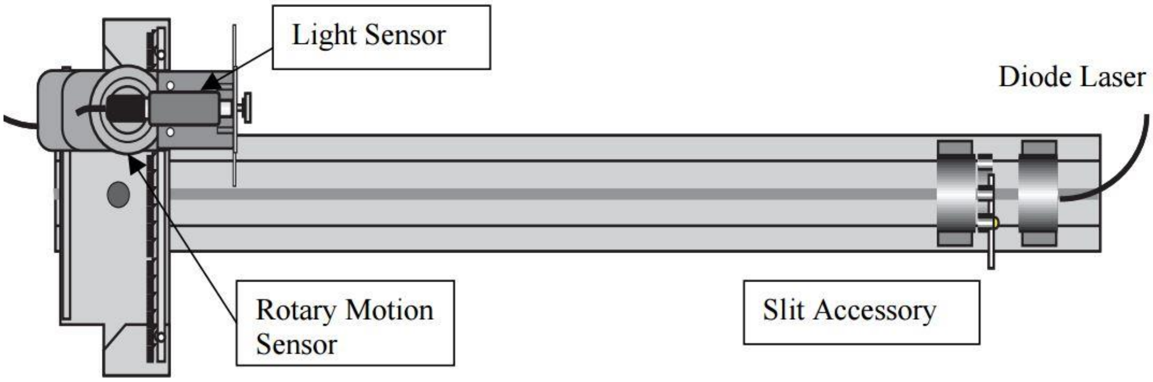
   b. How does the separation of the slits affect the spacing of the diffraction pattern?

The greater the separation of the slits the smaller the spacing of the diffraction pattern. There is a inverse relationship.

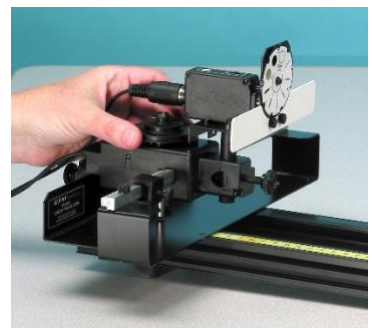
   c. Are there any other variables which you believe might contribute to a different size diffraction pattern?

The greater the wavelength the greater the spacing in the diffraction pattern.

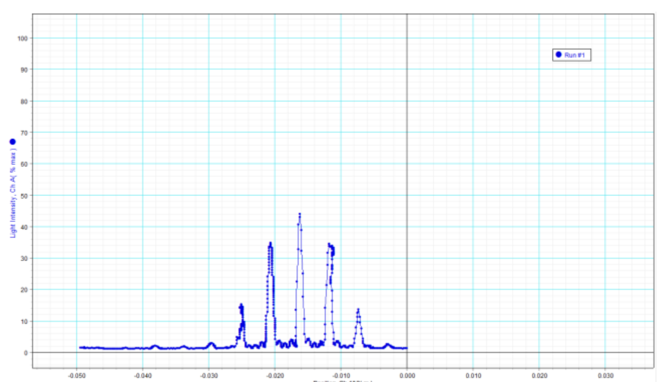
4. Remove the Viewing Screen and attach the Linear Translator apparatus in its place. If you look underneath the apparatus, you will notice a nut on the bolt. Loosen this nut until it has almost been fully removed and slide the apparatus into the groove at the bottom of the Optics Bench. Tighten the bolt to lock it into place. Look at the image below for final setup reference.



5. Open the DataStudio file in the assignment. This file will record light intensity as a function of linear position along the axis parallel to the plane of the two slits.



6. To take data, start with the Light Sensor positioned in the center of the Linear Translator. Press "Start" and *slowly* adjust the position of the Light Sensor. However, do not directly push on the rotary motion sensor, as this can cause vibrations which will drastically affect your data. Instead, ***slowly*** rotate the spool portion of the Rotary Motion Sensor (see figure to the right for reference). Be sure to scan the left and right portions of the diffraction pattern.
7. Insert a screenshot of your graph.



8. What do you notice about the linear spacing between the peak intensity of each consecutive set of fringes?

It is about the same.

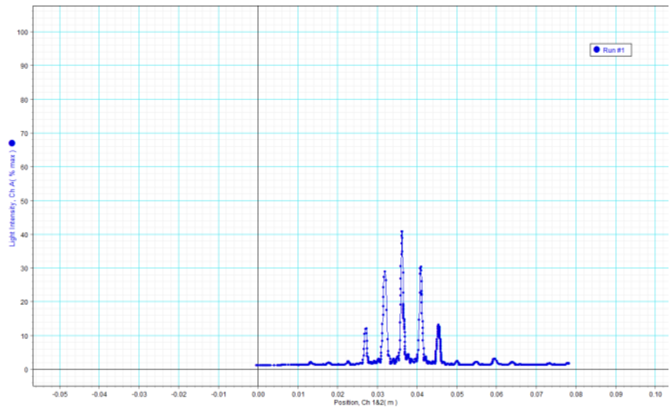
9. Based on your proportionalities in part 3a-3c, how would you equate the linear separation of fringes Δx as a function of wavelength λ, slit-to-screen distance L, and slit separation d.

$$\Delta x_{double\ slit\ fringes} = \lambda\, L/d$$

Experimental Design Pt. 2 – Diffraction Grating

1. What happens when you have more than one slit creating a diffraction pattern? Does the amount of slits affect the type of pattern?

2. A **<u>Diffraction Grating</u>** is a series of slits which are extremely close together. The type of diffraction gratings you will be working with today consist of slits of width 0.04 mm and separation of 0.125 mm.
3. Place the Viewing Screen in front of the Linear Translator. You do not need to remove the Linear Translator.
4. Rotate the Multiple Slit Set to the "Multiple Slits" portion. Experiment with the different diffraction gratings until you have a good idea as to how the amount of slits in the grating affects the diffraction pattern?
5. What do you notice happens to the width of each fringe as the amount of slits in the diffraction grating increases? The width increases
6. Insert a screenshot of the graph produced with 5 slits.



Experimental Design Pt. 3 – Single Slit

1. You will be attempting to determine the relationship between the size of a single slit and the diffraction pattern formed at a significant distance.
2. Replace the Multiple Slit Set with the Single Slit Set on the Optics Bench. Begin rotating the Single Slit Set to different settings until you have experimented enough to have a rough idea as to the factors which affect the diffraction pattern.
3. You might notice that there are two sections called Patterns and Circular Apertures. You may experiment with these setting if you wish, however they are not part of this laboratory analysis.
4. How do the following variables affect the diffraction pattern?
    a. How does the slit-to-screen distance affect the spacing of the diffraction pattern?

The smaller the slit-to-screen distance the smaller the spacing of the diffraction pattern

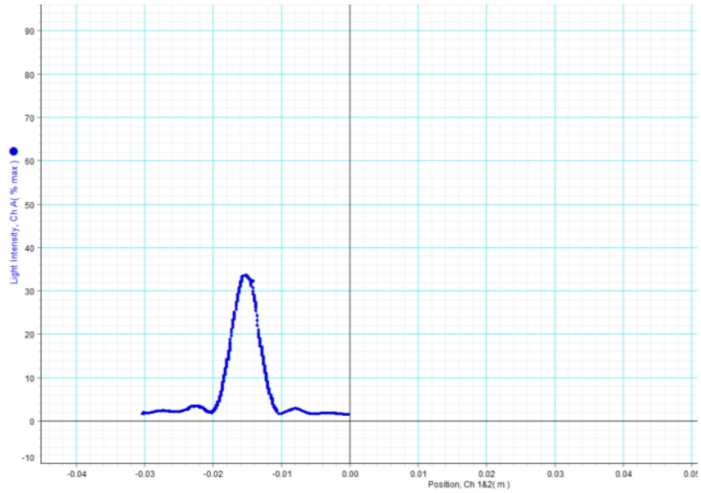
    b. How does the width of the slit affect the size of the diffraction pattern?

The larger the width of the slit, the larger the diffraction pattern.

    c. Are there any other variables which you believe might contribute to a different size diffraction pattern?

The smaller the slit-to-screen distance the bigger the diffraction pattern

5. Again, use the Linear Translator and the DataStudio file to scan the Light Intensity as a function of Linear Position. Insert a screenshot of the graph below.



6. How does this diffraction pattern differ from the double slit or diffraction grating?

Doesn't have as many peaks.

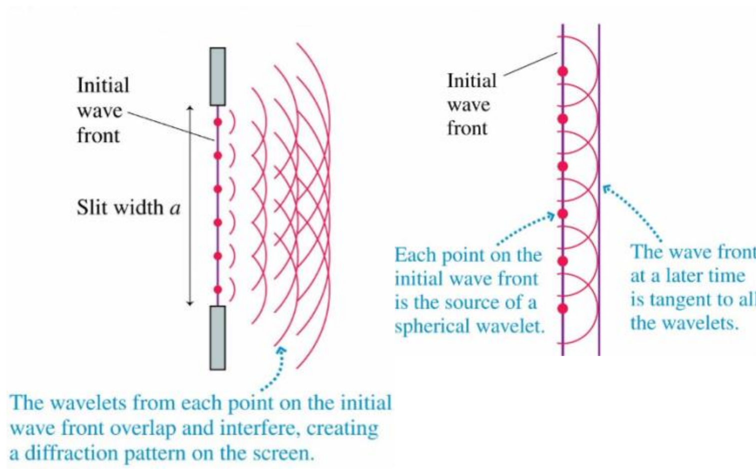
7. Using your proportionalities from Question 4a-c, How would you equate linear separation of fringes Δx as a function of wavelength λ, slit-to-screen distance L, and slit width a.

$$\Delta x_{single\ slit\ fringes} = \lambda L / a$$

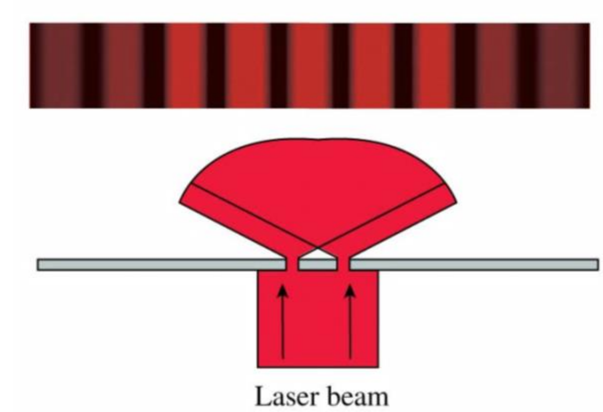
Analysis

1. You might have noticed that even when you only had 1 slit, interference fringes still formed. How can you still get interference when there is only 1 slit?

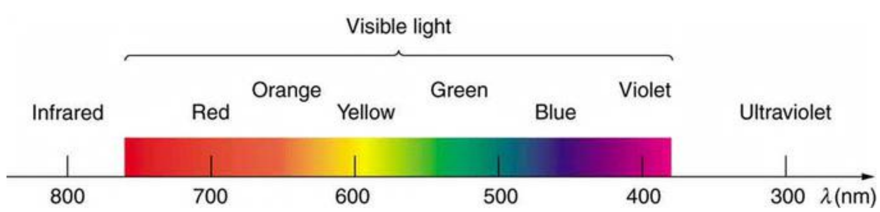
   - Dutch Physicist Christiaan Huygens developed a geometrical model to visualize how *any wave* can be thought of as the result of an interaction between tiny point sources called *wavelets*. As the distance from the slit increases, it is clear to see that the wave front seems somewhat straight, however we still receive some destructing interference as we are not directly in front of the slit.



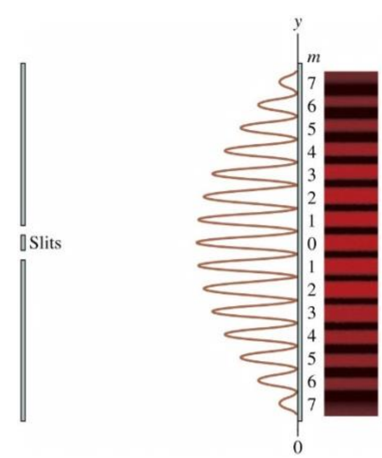
2. Suppose a laboratory experiment produces a double-slit interference pattern on a screen. If the left slit is blocked, the new pattern formed on the screen will look like:



3. A color-blind scientist measures the fringe separation of two consecutive fringes produced by a double slit with slit separation of 0.125 mm and slit-to-screen length of 1 m. The separation of the two consecutive fringes is 4.8 mm. What color of light is on the viewing screen? Yellow (600 nm).



4. Suppose that you measure the distance between two consecutive fringes to be 5 mm. How far would the 7th fringe be from the central maximum? 35 mm



Save this file as a PDF (NOT WORD!) document for submission.