Diffraction and Interference

Object: To observe constructive and destructive interference of light using a diffraction grating and a single slit, and to use this phenomenon of interference to measure the wavelength of light.

LASER SAFETY

A low wattage laser will be used during this lab. Before connecting the power supply to the laser, the laser should be checked to make sure it is turned off, and the laser should be mounted in the optics bench such the laser is pointed at the screen. For the safety of each individual, the laser should only be turned on while the laser is mounted in the optics bench and while data is being collected. The laser should be turned off as soon as data has been collected. Be aware of reflected beams; reflected beams can be as dangerous as an original beam from the laser. The laser should only be pointed at the screen/paper. Any individual seen pointing the laser at anything other than the intended screen will be asked to leave, and the individual will receive a zero (0) for the lab.

PSA: Shining a laser at an airplane is a Federal Felony that will result in jail time and fines.

Part I. Measuring the wavelength of the laser light with a diffraction grating

1. Snap a red laser into the optical bench such that it is approximately 90 cm from the viewing screen. The viewing screen should have a square nut and a thumbscrew to allow installation. *The viewing screen can be slid up and down the optics bench without totally removing the thumb screw. If the thumbscrew is loosened slightly, the viewing screen can be slid along the optics bench. The viewing screen can be removed from the optics bench by sliding it off the end. Again, the thumbscrew does not need to be totally removed to remove the viewing screen from the optics bench. Please take care not to lose the square nut located in the slot of the optics bench when loosening the thumbscrew. When the viewing screen is removed from the optics bench for Part II, make sure the square nut is still securely threaded to the thumbscrew.*
2. Tape a piece of paper to the viewing screen so you can mark the diffraction patterns. Do not mark directly on the viewing screen.
3. Mount the bracket that has the Diffraction Grating taped to it on the optics bench somewhere between the laser and the viewing screen. The Diffraction Grating should be facing the screen.
4. Plug in the laser and slide the switch on the back of the laser to the on position. At the very least, you should see a bright spot (Central Maximum) approximately centered on your viewing screen. Adjust the position of the diffraction grating by sliding it on the optics bench such that the 1st order maximums are also visible. You should position the diffraction grating such that the distance between the 1st order dots is maximized.

5. Determine the distance (L) between the diffraction grating and the viewing screen. Note that the brackets that snap on to the optics bench all have pointers near their bases. The distance between the diffraction grating and the pointer on the base is 1.5cm.
6. Using a sharp pencil, carefully mark the positions of the 1st order maximums on the paper taped to the screen.
7. After the centers of the 1st order maximums have been marked, turn the laser off.
8. Using a ruler or vernier caliper, measure the distance (2y) between the First Order maximums. Record this information on the data sheet. You may find it easier to remove the viewing screen from the optics bench to make accurate measurements. Note that 2y is being measured in an attempt to minimize error.
9. The spacing of the lines of the diffraction grating is recorded on the diffraction grating. Using this information and the other data collected, determine the wavelength of the red laser light. Note that you probably *should not* use the small-angle approximation for this part. [Hint: Draw a picture and use tanΘ to determine Θ. Also note that 2y was measured, not y.] Record the experimental wavelength you calculated for your red laser, and compare it to the value written on the laser. The experimental value should be in close agreement. Use the wavelength that was experimentally determined for the remainder of the lab.
10. If the viewing screen was removed to make measurements, remount the viewing screen on the optics bench.
11. Now predict the distance between the grating and the viewing screen such that the **2^{nd} order** maximums from a green laser (λ = 532 nm) will be located at the very edge of the viewing screen. After the prediction has been recorded on the data sheet and the grating has been properly positioned such that the 2nd order maximums will be located at the edge of the screen, the TA will visit your station with a green laser.
12. After the TA visits your station, carefully remove the viewing screen without losing the square nut and remove the diffraction grating from the optics bench.

Part II. Single Slit: Predictions and calculations.

For a single slit, the small angle approximation can be used: sinΘ ≈ tanΘ.

To more accurately measure 2y for the 1st through 6th order minimums, the distance from the screen to the slit will be set to three meters. Using a slit width of 0.16mm, a slit to screen distance of three meters, and the experimental wavelength of the laser found in Part I, calculate 2y for the third order minimum (m = ±3) on the data sheet.

After you have calculated the 2y for the third order minimum, an Excel spreadsheet should be created to perform the following:

A. Calculate 2y for the 1st through 6th order minimums.
B. Compare the calculated 2y values to the actual 2y values collected in Part III by calculating a percent difference.
    a. $Percent\ Difference = \frac{|A-B|}{(A+B)/2} x100\%$
C. Provide appropriate labels for columns and/or rows.

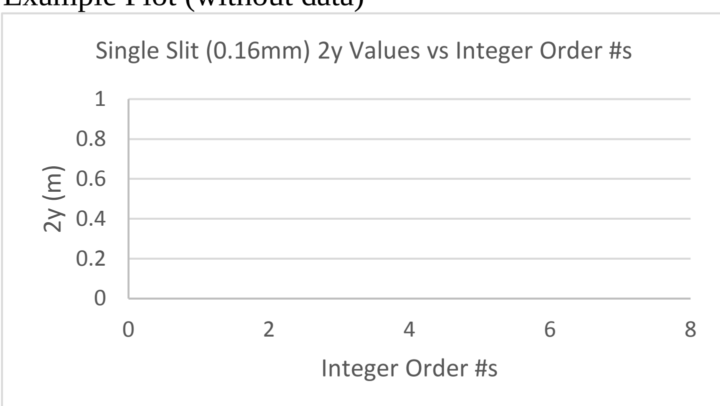
Part III. Single Slit: Apparatus set-up and data collection.

The slit can be accurately positioned by using a two meter meterstick in combination with the scale that is on the optics bench.

1. Snap the bracket with the single slit on to the optics bench and use the two meter meterstick to position the optics bench such that the single slit is three meters away from the screen.
2. Rotate the dial on the bracket of the single slit such that the laser will pass through the slit with a width of 0.16mm (a = .16)
3. Plug in the laser and slide the switch on the back of the laser to the on position. If necessary carefully use the adjustment screws on the back of the laser to adjust the beam horizontally and vertically such that the beam passes through the 0.16mm single slit.
4. Use masking tape to secure a piece of paper to the screen.
5. Carefully mark the centers of the dark spots (destructive interference) such that 2y can be measured for the 1st through 6th order minimums.
6. After the centers of the dark spots have been marked, turn the laser off and remove the paper from the screen.
7. Use a Vernier caliper to measure 2y for the first six order minimums and record the values in the Excel Spreadsheet.
8. Use Excel to determine the percent difference for each order.

Part IV. Determining Wavelength from the Single Slit Data

Example Plot (without data)



Using the <u>*experimental*</u> data, create an Excel scatter plot of '2y vs Integer Order #s' (i.e. the x axis will be m = 1, 2, 3, 4, 5, 6) and determine the wavelength of the laser from the slope. [Hint: the slope is related to the wavelength, but the slope will not be equal to the wavelength.]

Compare the value of the wavelength from Parts I and III by calculating a percent difference.

Part V. Prepping for Leaving Lab

Before you leave your station, place all of the components on the optics bench. This should include the laser, the single slit set, the diffraction grating, and the viewing screen. The laser should be turned off and unplugged.

Name: ______________________________ **Banner ID: _____________________________**

Lab Group ID: ______________________ **Number of Lab Partners: ________________**

Data Sheet
Diffraction & Interference

Part I Diffraction Grating

Red Laser

Distance from the diffraction grating to the viewing screen . . . . L = _______________ (mm)

Distance between 1st Order Maximums ……..…………………………..2y = _______________ (mm)

Number of lines per unit width of the diffraction grating . . . . N = _______________

Calculate the value of the wavelength of the red laser. (work must be shown)

Experimental wavelength of the red laser..………..…………………..………λ = _______________ (nm)

Documented wavelength of the red laser as stated on the laser……………λ = ________________ (nm)

Part I continued -- Green Laser

Determine the distance between the grating and the screen such that the 2nd order maximums produced by the green laser will just fit on your viewing screen? Show your work.

If the distance between the grating and screen (L) was kept exactly the same, would the spacing between the 1st order maximums produced by the green laser be narrower or wider as compared to the 1st order maximumss produced by the red laser? Explain your prediction.

Part II Single Slit: Predictions and Calculations

Screen to Slit Distance (m)	
Slit Width (mm)	
Experimentally Determined Laser Wavelength (nm) from Part I	
Calculation of 2y for the 3rd order minimum (work must be shown)	

Part III Single Slit: Data Collection and Excel

Attach tabulated data from the Excel Spreadsheet.

Part IV. Determining wavelength from the Single Slit Data

Attach the Excel Plot

Wavelength from Part I (nm)	Wavelength from Part IV (nm)	Percent Difference

Show the work for percent difference:

Before you leave your station, place all of the components on the optics bench. This should include the laser, the single slit set, the diffraction grating, and the viewing screen. The laser should be turned off and unplugged.

The switch for the laser is in the off position.	Yes	No
The power supply is detached from the laser and the outlet.	Yes	No
Is the Viewing Screen attached to the optics bench?	Yes	No
Is the diffraction grating mounted on optics bench?	Yes	No