# Pre-Lab Information

**Purpose** Observe diffraction and explain why it occurs.

**Time** Approximately 45 minutes

**Question** How does diffraction occur?

**Hypothesis** If the line spacing on a diffraction grating decreases, then the diffraction angle will increase because it is dependent on wavelength and line spacing.

**Variables:** *Independent Variable:* diffraction line spacing

*Dependent Variable:* diffraction angle

*Constant:* wavelength

**Summary** The spreading of waves around the edge of a barrier or small obstacle is known as diffraction. The concept of diffraction applies to all kinds of waves, including mechanical waves (like sound and water waves) and electromagnetic waves (such as radio waves, visible light, and X-rays). Because of the relatively short wavelengths of light, it is difficult to observe diffraction without very special equipment. However, with diffraction of light through a gap or around a barrier, we can observe a diffraction pattern that can be measured in certain ways. These measurements can inform us regarding the actual angle of diffraction, and even tell us the wavelength of the light.

In this lab, you will use a laser of a certain wavelength to study diffraction. The light from the laser will be passed through diffraction gratings, which have a condensed pattern of lines. Since the spacing of these lines corresponds to the wavelengths of light, diffraction occurs. As the wavelength of the laser light used is a constant, but treated as an unknown, you will use a formula based on dimensions of the diffraction pattern to calculate wavelength.

While you will determine the wavelength of the laser, it remains the same throughout the experiment, while the diffraction grating and line spacing are varied. After doing calculations to determine diffraction angles using the different gratings, you will complete your data tables and write brief observations and comparisons about the results. This will prepare you for analyzing the data in your lab report.

# Safety

* Always wear safety goggles when performing an experiment, especially when using lasers.
* Make sure you understand the proper use of the laser and the diffraction grating, and never point the laser at other people.
* Behavior in the lab needs to be purposeful.
* Report all accidents—no matter how big or small—to your teacher.

# Lab Procedure

1. **Gather materials.**

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| * Table
* Laser
* Diffraction gratings
* Holder for diffraction gratings
 | * Protective eyewear
* Meter stick
* Scientific calculator
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1. **Set up the laser and the diffraction gratings.**
	1. Position the table on which you will place the laser near the wall or screen where you will project your diffraction patterns. Make sure the table has a level surface.
	2. Position the laser near one end of the table. Place diffraction grating 1 in front of the laser. The distance, *D*, between the grating and the wall or screen will be adjusted from a few centimeters to almost a meter during the experiment, so allow room to move the table or laser and grating.
	3. Connect the power source for the laser. Be sure to wear protective eyewear and turn on the laser to test it. Check the alignment of the laser so that it is perpendicular to the screen or wall.
2. **Calculate the diffraction grating line spacing in nanometers.**
	1. Determine the diffraction grating line spacing in nanometers (nm). Depending on the exact type of gratings your teacher supplies, the line spacing reported on the grating may be in lines/inch, lines/cm, or lines/mm. Confirm with your teacher which grating line value to use.
	2. As an example, the first grating used in this lab had a line spacing of 12,700 lines per inch. Since one inch = 25,400,000 nm, dividing this by 12,700 lines gives us the *d* spacing of the grating in nanometers, which in this case was 2000 nm. Calculate the value of *d* in nanometers for your grating, and record it in Table A.
3. **Gather diffraction pattern data using grating 1.**
	1. Position the grating at about 30 cm from the wall or screen and turn the laser on. The exact distance for *D* does not matter, although smaller distances will create a tighter, more difficult pattern to measure.
	2. Measure the exact distance of *D* in centimeters (cm), and record it in Table A to tenths of a centimeter. Then measure the exact distance of *y*, and record it in Table A to tenths of a centimeter. Remember that *y* is the distance from the central bright point in the pattern to the center of the first bright band on either side.
	3. Adjust the laser and grating to increase the distance *D* by a few centimeters. Again, measure the exact distance of *D*, and the distance of *y* in the resulting pattern. Record your data in Table A to tenths of a centimeter. Convert your measurements of *D* and *y* to nanometers, since you will use these values to calculate the wavelength of the laser in nanometers. Use scientific notation for large numbers.
	4. Repeat the previous step four more times, gathering data at different distances of *D* until Table A is complete.
4. **Gather diffraction pattern data using gratings 2 and 3.**
	1. Check the line spacing values for the next grating you will use, and convert to line spacing in nanometers as you did earlier. Record this value in Table B, and then proceed with Step 4 as you did earlier, this time using the new grating.
	2. Once you have taken down the data and made conversions to nanometers, repeat the line spacing conversion for the third grating. Then repeat Step 4, recording your data in Table C. Your teacher may guide you in specific positioning of the laser and gratings to determine a desired data set.
5. **Shut off the laser.**
	1. Turn off the laser, unplug it, and put it away, along with the diffraction gratings, as directed by your teacher.
6. **Determine the diffraction angle of the laser through each diffraction grating.**
	1. Now that you have all the data, determine the diffraction angle. While the wavelength of the laser remained the same throughout the experiment, the line spacing of the diffraction gratings changed. This had an effect on the diffraction angles. To determine the diffraction angle, use the formula

tan *θ* = *y/D*

where *θ* is the angle of diffraction, *y* is the distance from the central bright spot to the first bright band in nanometers, and *D* is the distance from the grating to the screen, also in nanometers. Record the diffraction angles in Tables A–C.

* 1. How did these diffraction angles compare? Calculate an average diffraction angle for each grating, and compare them in Table E. How did they differ? Did you see any relationship between the angles and the line spacing on the gratings? Record your observations in
	Table E.
1. **Determine the approximate wavelength of the laser.**
	1. Now that you have all the data, use it to determine the wavelength of the laser by performing some calculations. To calculate the wavelength, use the diffraction grating equation

*d* sin *θ* = *nλ*

where *d* is the line spacing of the grating in nanometers, *θ* is the angle of diffraction, *n* is the order number (and equal to 1 in this lab), and *λ* is wavelength in nanometers. Rearrange the equation to solve for wavelength for all three sets of grating data, in Tables A–C.

* 1. How did these wavelengths compare? Calculate an average wavelength as determined for each grating, and compare them in Table D. Were the wavelengths similar, or was there significant deviation? If so, why do you think they differed? Record your observations in
	Table D.

# Data

Record your data either in your lab notebook or in the tables below.

**Table A**

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| **Diffraction Measurements: Grating 1** |
| **Grating Line Spacing** **(*d*)**  | **Distance to****Screen****(*D*)** | **Distance to** **First Band****(*y*)**  | **Diffraction Angle****(*θ*)** | **Wavelength****(*λ*)** |
| **(nm)** | **(cm)** | **(nm)** | **(cm)** | **(nm)** | **(°)**  | **(nm)** |
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**Table B**

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| **Diffraction Measurements: Grating 2** |
| **Grating Line Spacing** **(*d*)**  | **Distance to****Screen****(*D*)** | **Distance to** **First Band****(*y*)**  | **Diffraction Angle****(*θ*)** | **Wavelength****(*λ*)** |
| **(nm)** | **(cm)** | **(nm)** | **(cm)** | **(nm)** | **(°)**  | **(nm)** |
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**Table C**

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| **Diffraction Measurements: Grating 3** |
| **Grating Line Spacing** **(*d*)**  | **Distance to****Screen****(*D*)** | **Distance to** **First Band****(*y*)**  | **Diffraction Angle****(*θ*)** | **Wavelength****(*λ*)** |
| **(nm)** | **(cm)** | **(nm)** | **(cm)** | **(nm)** | **(°)**  | **(nm)** |
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**Table D**

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| **Comparison of Diffraction Angles** |
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**Table E**

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| **Observations on Determined Wavelength** |
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