AP Physics: Lab #12

Interference Patterns

Name _____ Hour _____

Lab Partners _____

Purpose:

* Observe and analyze patterns of double-slit and diffraction grating interference.
* Calculate the wavelength of a laser light.

Equipment:

Laser
Double slit patterns of known width
Diffraction gratings of known width
Meter stick
Screen

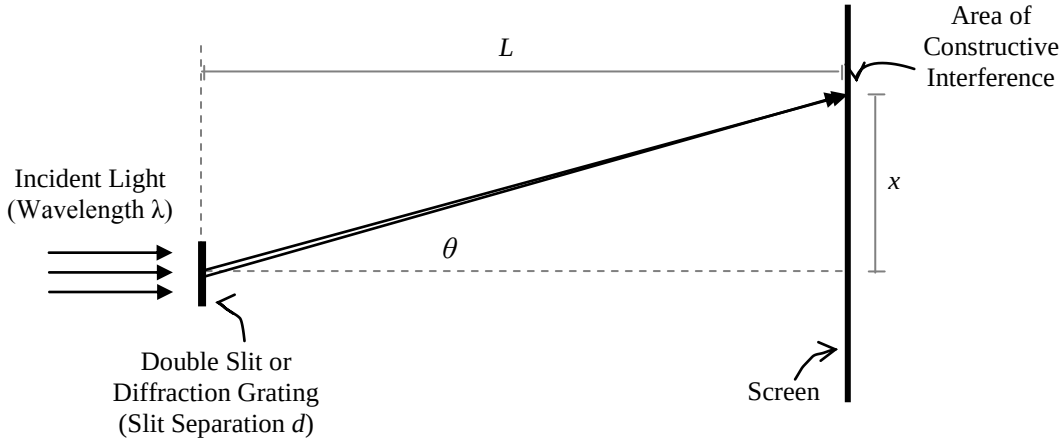
Introduction:

When a ray of light is passed through a double-slit or diffraction grating, it is divided into separate rays, which can then cause interference patterns. Areas of constructive interference are viewed as bright spots of light, and occur where waves are in phase. On the other hand, areas of destructive interference are viewed as dark spots, and occur where waves are 180° out of phase. The pattern of interference depends on the distance between slits *(d)*, and the length from the slit pattern to the screen on which the pattern is observed *(L)*. The location of each area of interference can be described by either its distance from the center of the screen *(x)*, or the angle of deviation of the ray of light *(θ)*. These measurements are shown on the diagram below. For either a double-slit or diffraction grating pattern, the areas of constructive interference can be described by the equation:

$$d \cdot \sin\theta = m \cdot \lambda \qquad \text{(where } m = 1, 2, 3 \ldots \text{)}$$

In addition, for a double-slit pattern, the deviation of the light occurs at a sufficiently small angle so that the sine and tangent of the angle are approximately equal. The equation above can then be rearranged to obtain the equation:

$$x_m \approx \frac{m \cdot \lambda \cdot L}{d} \qquad \text{(where } m = 1, 2, 3 \ldots \text{)}$$



NOTE: Figure not drawn to scale.

Procedures:

(CAUTION: Safety procedures must be followed when working with lasers. Do not look directly into the laser or its reflected beam. Never stand directly in front of the laser. Do not pick up or move the laser when it is on.)

Set up the helium-neon laser approximately 2 meters from the screen. Choose a double-slit pattern and mount it near the laser. Record the given slit separation on Data Table A. Adjust the laser beam so that it is aimed through the double-slit pattern at a right angle to the screen. If necessary, adjust the location of the double-slit pattern until an interference pattern appears on the screen. Measure the distance from the double-slit pattern to the screen and record that distance on Data Table A. Measure the distance from the central maximum to the center of the first order fringe on both the left and right sides, and record these distances on Data Table A. If possible, also measure the distances from the central maximum to the second and third order fringes, recording these distances on Data Table A.

Repeat these procedures for two additional double-slit patterns, recording your measurements on Data Table A.

Repeat these procedures for three diffraction grating patterns, recording your measurements on Data Table B. Remember to convert the number of grooves per millimeter to an actual slit separation for the values on Data Table B.

Calculations:

Use the average distance from the central maximum to the left and right fringes to calculate an experimental value for the wavelength of the laser light for each of the three double-slit patterns.

Use the average distance from the central maximum to the left and right fringes to calculate an experimental value for the wavelength of the laser light for each of the three diffraction grating patterns. *(HINT: Avoid the small angle approximation for diffraction grating calculations.)*

Calculate the average experimental wavelength of the laser light for the double-slit and diffraction grating interference patterns.

Use a given manufacturer's value for the wavelength of the laser light to calculate the percent error for the double-slit and diffraction grating interference patterns.

Analysis:

To summarize the lab report, answer the application questions below in complete sentences. In addition, include a brief statement of the overall results for the lab.

- Why is a laser a good source of light for this experiment?
- Which interference pattern produced the most accurate measurements: double-slit or diffraction grating? Why does this pattern produce better results?
- Draw and label a diagram showing two rays of light in a double-slit interference pattern. Label the measurements for d, L, x_1, and θ, using values from one of your trials on the diagram.
- Sketch an example of the interference pattern formed on the screen by the double-slit. How would this interference pattern be affected if . . . d was increased? . . . green light was used instead of red?
- Sketch an example of the interference pattern formed on the screen by the diffraction grating. How does this pattern differ from the pattern of interference formed by the double slit? How would this interference pattern be affected if the diffraction grating included more grooves per millimeter?

Lab Report:

Title Page, Objectives, & Overall Report – 5 pts
Procedures – 3 pts
Data Table – 4 pts
Calculations – 8 pts
Analysis – 13 pts

Data Table A: Double Slit Interference

Length to the screen *(L)* = _____

	1st Order Fringe			2nd Order Fringe			3rd Order Fringe		
Slit Distance *(d)*	Left (x_1)	Right (x_1)	Wave-length (λ_1)	Left (x_2)	Right (x_2)	Wave-length (λ_2)	Left (x_3)	Right (x_3)	Wave-length (λ_3)

Average Calculated Wavelength (λ) = _____

Percentage Error = _____

Data Table B: Diffraction Grating

Length to the screen *(L)* = _____

	1st Order Fringe			2nd Order Fringe			3rd Order Fringe		
Slit Distance *(d)*	Left (x_1)	Right (x_1)	Wave-length (λ_1)	Left (x_2)	Right (x_2)	Wave-length (λ_2)	Left (x_3)	Right (x_3)	Wave-length (λ_3)

Average Calculated Wavelength (λ) = _____

Percentage Error = _____