INTERFERENCE OF DIFFERENT WAVELENGTHS

Purpose

The purpose of this experiment is to examine the diffraction and interference patterns formed by laser light of two different wavelengths passing through two slits. The wavelength of each laser beam will be determined using the equations from theory.

Materials and Equipment

- Data collection system
- OS-8441 Wireless Diffraction Scanner
- OS-8442 Diffraction Slits
- OS-8508 1.2 m Optics Track
- OS-8525 Red Diode Laser
- OS-8458B Green Diode Laser

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Do not stare into the laser beam.

Background

When light passes through two slits, the two light rays emerging from the slits interfere with each other and produce interference fringes. The angle to the maxima (bright fringes) in the interference pattern is given by

$$d \sin\theta = m\lambda$$

where d is the slit separation, θ is the angle from the center of the pattern to the mth minimum, λ is the wavelength of the light, and m is the order (0 for the central maximum, 1 for the first side maximum, 2 for the second side maximum, and so forth). See Figure 1.

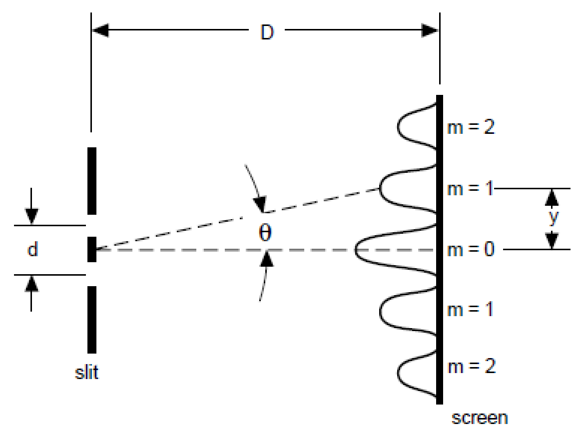

Figure 1: Interference fringes.

Since the angles are usually small, it can be assumed that

$$\sin\theta \approx \tan\theta$$

From trigonometry,

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

where y is the distance on the screen from the center of the pattern to the mth maximum and D is the distance from the slit to the screen as shown in Figure 1. The interference equation can thus be solved for the distance from the center to the mth maximum

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

If y is plotted versus m, the wavelength can be determined by the slope of the line

$$\lambda = \frac{d}{D} \cdot \text{slope}$$

Procedure

1. Set up the red laser at one end of the optics track and place the diffraction slits about 3 cm in front of the laser (Figure 2).

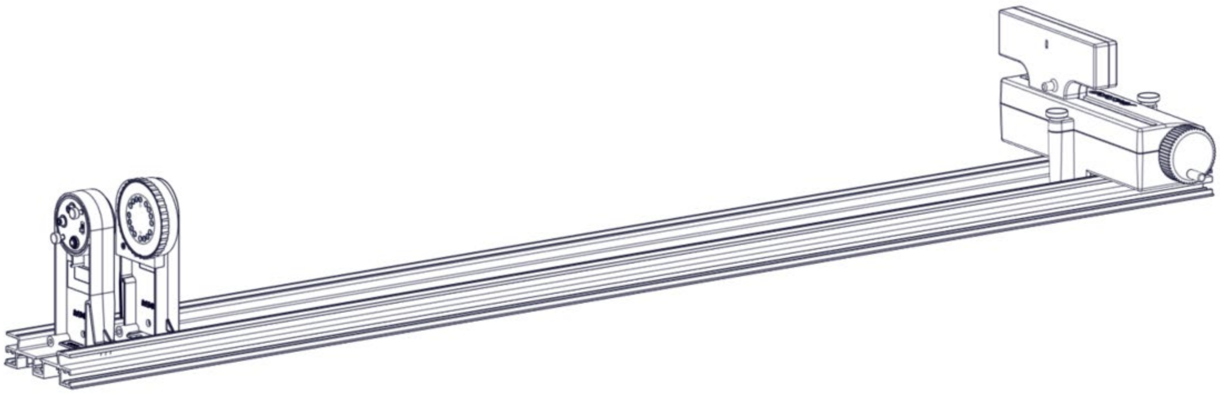

Figure 2: Experiment setup.

2. Put the Diffraction Scanner on the other end of the optics track so that the aperture faces the laser. Set the aperture width to 0.5 mm.

3. Select the 0.04 mm double slit with 0.25 mm slit separation by rotating the slit disk until the slit is centered in the slit holder. Turn on the laser and adjust the position of the laser beam until it is centered on the slit.

4. Measure the distance from the slit to the Diffraction Scanner screen. Record the slit-to-screen distance in Table 1.

5. Record the slit separation in Table 1.

6. Open your software then connect the Diffraction Scanner to your device.

7. In the software, set up a graph of Light Intensity versus Position.

8. Turn the Diffraction Scanner crank until the scanner head is at the far-left position.

9. Start recording data then slowly turn the crank until the scanner head is at the far-right position. Stop recording data when finished.

10. Use the software graph tools to measure the distance between the central maximum and the first order ($m = 1$) maximum and record this distance in Table 2. Repeat this measurement for the second, third, fourth, and fifth maxima.

11. Repeat the steps using the green laser.

Data Collection

Table 1: Slit-to-screen distance and slit separation.

Slit-to-screen distance (mm)	
Slit separation (mm)	

Table 2: Interference and diffraction data for a double slit.

m	Red Distance from center to m (mm)	Green Distance from center to m (mm)
1		
2		
3		
4		
5		

Table 3: Wavelength of laser light.

Laser Color	Slope (mm)	Wavelength (nm)
Red		
Green		

1. Graph y versus m for the red laser and green laser using the data from Table 2.

2. Use the software graph tools to determine the best fit line and slope for each data set. Record the slope in Table 3.

3. Calculate the wavelength for each laser in nm using the slope from the graphs. Record the results in Table 3.

Questions and Analysis

1. Which color of laser light has a longer wavelength? How does the wavelength determined from your data compare to the wavelength labeled on each laser?

2. Does the distance between maxima increase, decrease, or stay the same when the wavelength increases? What type of mathematical relationship is this?

3. If you were to repeat this experiment using blue light, would you expect the distance between the maxima to be larger or smaller than the red and green light? Justify your answer.