DIFFRACTION FROM A SINGLE SLIT

Purpose

The purpose of this experiment is to examine the diffraction pattern formed by laser light passing through a single slit and verify that the positions of the minima in the diffraction pattern match the positions predicted by 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

Safety

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

- Do not stare into the laser beam.

Background

When diffraction of light occurs as it passes through a slit, the angle to the minima in the diffraction pattern is given by

$$a \sin\theta = m\lambda$$

where a is the slit width, 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 (1 for the first minimum, 2 for the second minimum, counting from the center out). See Figure 1.

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

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

From trigonometry,

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

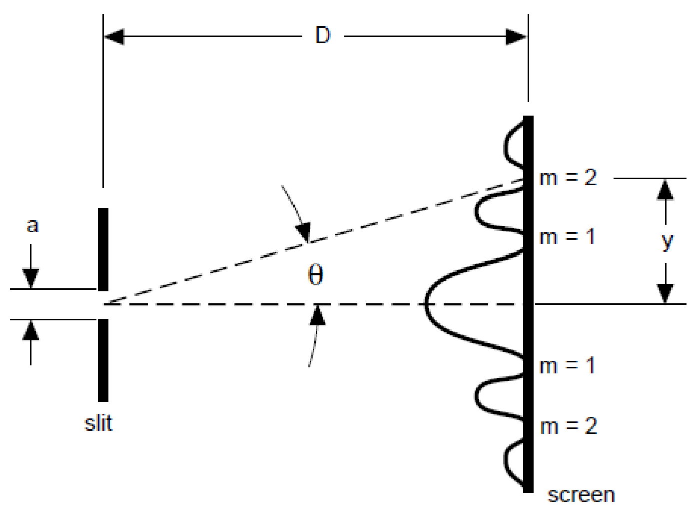

Figure 1: Single slit diffraction pattern.

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

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

Procedure

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

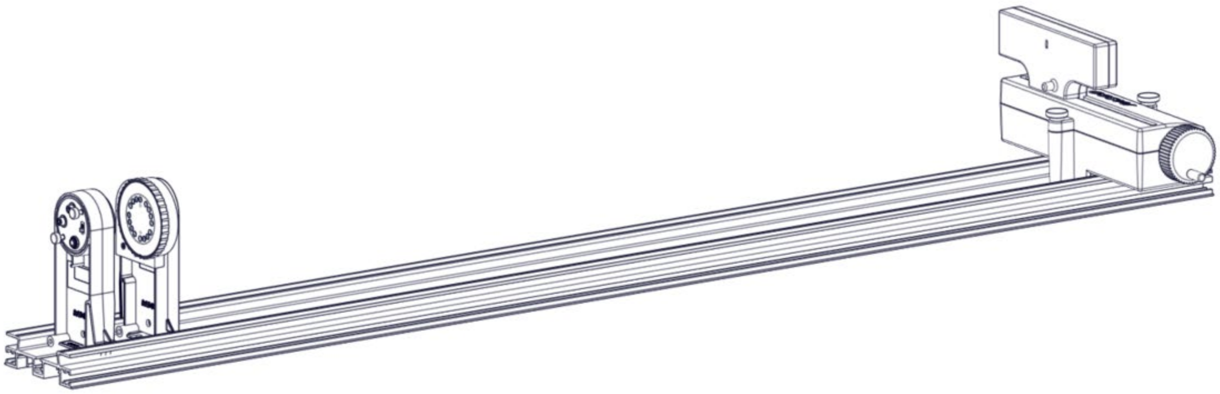

Figure 2: Experiment setup.

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 1.5 mm.

3. Select the 0.02 mm single slit by rotating the slit disk until the 0.02 mm 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 wavelength of the laser (labeled on the laser) 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 ($m = 1$) minimum and record this distance in Table 2. Also measure the distance between the central maximum and the second order ($m = 2$) minimum and record in Table 2.

11. Repeat the steps for the 0.04 mm, 0.08 mm, and 0.16 mm slits.

NOTE: If the light intensity caps off at 100%, decrease the Diffraction Scanner aperture width.

Data Collection

Table 1: Slit-to-screen distance and wavelength of the laser.

Slit-to-screen distance (mm)	
Wavelength	

Table 2: Slit width versus distance from central maximum to first and second order minimum.

Slit Width (mm)	First Order Distance (mm)	Second Order Distance (mm)	Slit Width from First Order Data (mm)	Slit Width from Second Order Data (mm)
0.02				
0.04				
0.08				
0.16				

1. Calculate the slit width using the data from the first order distances. Record the results in Table 2.

2. Calculate the slit width using the data from the second order distances. Record the results in Table 2.

Questions and Analysis

1. Does the distance between the central maximum and minimum increase or decrease when the slit width is increased? What type of mathematical relationship is this?

2. How does the first order distance compare with the second order distance?

3. Does the calculated slit width data corroborate with the theoretical slit width?