PHYS 1402
General Physics II

EXPERIMENT 9
DIFFRACTION AND INTERFERENCE OF LIGHT: MEASURING THE
WAVELENGTH OF LIGHT

I. OBJECTIVE

The objective of this experiment is to observe the interference pattern of a double slit and a diffraction grating and the diffraction pattern of a single slit and a hair or a very thin wire. In each case, measurement of the width of a portion of the projected interference-diffraction pattern will allow us to calculate the wavelength of the light.

II. APPARATUS

Laser, optical bench and optics kit containing double slits, single slits, diffraction grating and other accessories.

III. EXPERIMENTAL PROCEDURE

Procedure (1): Double Slit

1. Place laser and double slit on the optical bench and align such that light goes through the double slit. Measure the distance between the double slit and the screen (should be around $2\,\mathrm{m}$). Call this distance L

2. Observe the interference pattern on the screen. If the pattern is too narrow and the bright and dark fringes are too small to count, then use another double slit which will give you a wider pattern.

3. From the double slit plate, read the slit spacing. This is d.

4. Identify the $m = 0$ bright spot at the center of the pattern. Count bright spots on either side of the center bright spot until you get to a point where the bright spot looks like it is missing. You should be able to count 6, 7 or more bright spots. Measure the distance between the centers of the outermost bright spots. Call this distance $2y_m$ (see Figure (1)). What is m for your case?

5. Calculate the angle θ_m.

6. Calculate the wavelength λ from the constructive interference condition

$$d \sin \theta_m = m\lambda$$

7. Compare to the accepted value of the wavelength of the laser used by finding the percent difference.

8. Draw the pattern you observed as a series of bright and dark spots. Label the center bright and the outermost bright spots with their numbers. Also on this diagram show the distances you measured and the angle you calculated.

Procedure (2): Single Slit

1. Replace the double slit with a single slit and align on the optical bench.

2. Observe the diffraction pattern. If the pattern is too narrow and you can not count the dark spots, use a single slit of different width.

3. Measure the distance from slit to screen. Call this distance L.

4. Identify the central bright spot and compare its width and brightness to those of bright spots adjacent to it.

5. Identify the $m = 1$ dark spot and count darkspots outward. You should be able to count 6, 7 or more dark spots. Measure the distance between the outermost dark spots. Call this distance $2y_m$ (see Figure (2)). What is m for your case?

6. Calculate the angle θ_m.

7. Calculate the wavelength λ from the condition of destructive interference for the single slit
$$a \sin \theta_m = m\lambda \tag{1}$$
where a is the slit width.

8. Compare to the accepted value of the wavelength by calculating the percent difference.

9. Does this procedure give a better result than procedure (1)?

10. Draw a diagram showing the pattern you observed. Label the outermost dark spots with their numbers. On this diagram, show the distances you measured and the angle you calculated.

Procedure (3): Diffraction Grating

1. Replace the single slit with a diffraction grating. A diffraction grating is a piece of plastic with a very large number of slits on it. Align on the optical bench such that the light goes through the grating.

2. Observe the pattern and note differences between it and and those of procedures (1) and (2).

3. Measure the distance from grating to screen. Call this distance L.

4. Identify the $m = 0$ bright spot and the $m = 1$ bright spots on either side. Measure the distance between the two $m = 1$ bright spots. Call this distance $2y_1$ (see Figure (3)).

5. Calculate the angle θ_1.

6. Calculate the wavelength λ from the condition of constructive interference for the diffraction grating

$$d \sin \theta_1 = (1)\lambda \tag{2}$$

where the slit spacing d is the reciprocal of the number of lines per meter of grating.

7. Compare to the accepted value of the wavelength by calculating the percent difference.

8. Does this procedure give a better result than the previous procedures?

9. Draw a diagram showing the pattern you observed. Label the bright spots with their numbers. On this diagram, show the distances you measured and the angle you calculated.

Procdeure (4): Human Hair or Very Thin Wire

1. Get a human hair (any volunteers?) or a very thin wire and guess its thickness (diameter).

2. Tape the hair to the slit holder and place on the optical bench. Shine the light on the hair and observe the diffraction pattern on the screen. Which of the patterns of the previous procedures looks most like this pattern?

3. Measure the distance from slit to screen. Call this distance L.

4. Identify the central bright spot and compare its width and brightness to those of bright spots adjacent to it.

5. Identify the $m = 1$ dark spot and count darkspots outward. You should be able to count 6, 7 or more dark spots. Measure the distance between the outermost dark spots. Call this distance $2y_m$ (see Figure (2)). What is m for your case?

6. Calculate the angle θ_m.

7. Calculate the width of the human hair,w, from the condition of destructive interference for the single slit

$$w \sin \theta_m = m\lambda. \tag{3}$$

Use the accepted value of λ. How close is your guess to the measured width?

8. Draw a diagram showing the pattern you observed and on it label the central bright spot and label the outermost dark spots with their numbers. Also on this diagram indicate the distances you measured and the angle you calculated.

IV. ANALYSIS

1. For each procedure, record your data in the data table and perform all the necessary calculations.

2. For each procedure, draw a diagram showing the pattern your observed on the screen with the correct number of fringes. Show the distances L and $2y_m$ and the angle θ_m.

3. Write a conclusion summarizing your results. Comment on the success of this experiment. Which procedure gave the largest percent difference for the wavelength? What is this percent difference? Are your results in agreement with the theoretical predictions? What do you think are the two most important sources of error?

Experiment (11) Data Table				
	Double Slit	Single Slit	Diffraction Grating	Hair or Wire
Slits to screen distance L (m)				
Slit spacing, d (m)		$a =$		XXXXXXX
Fringe order, m				
Width of observed pattern $2y_m$ (m)				
mth fringe angular position, θ_m				
Wavelength of laser light, λ				$w =$