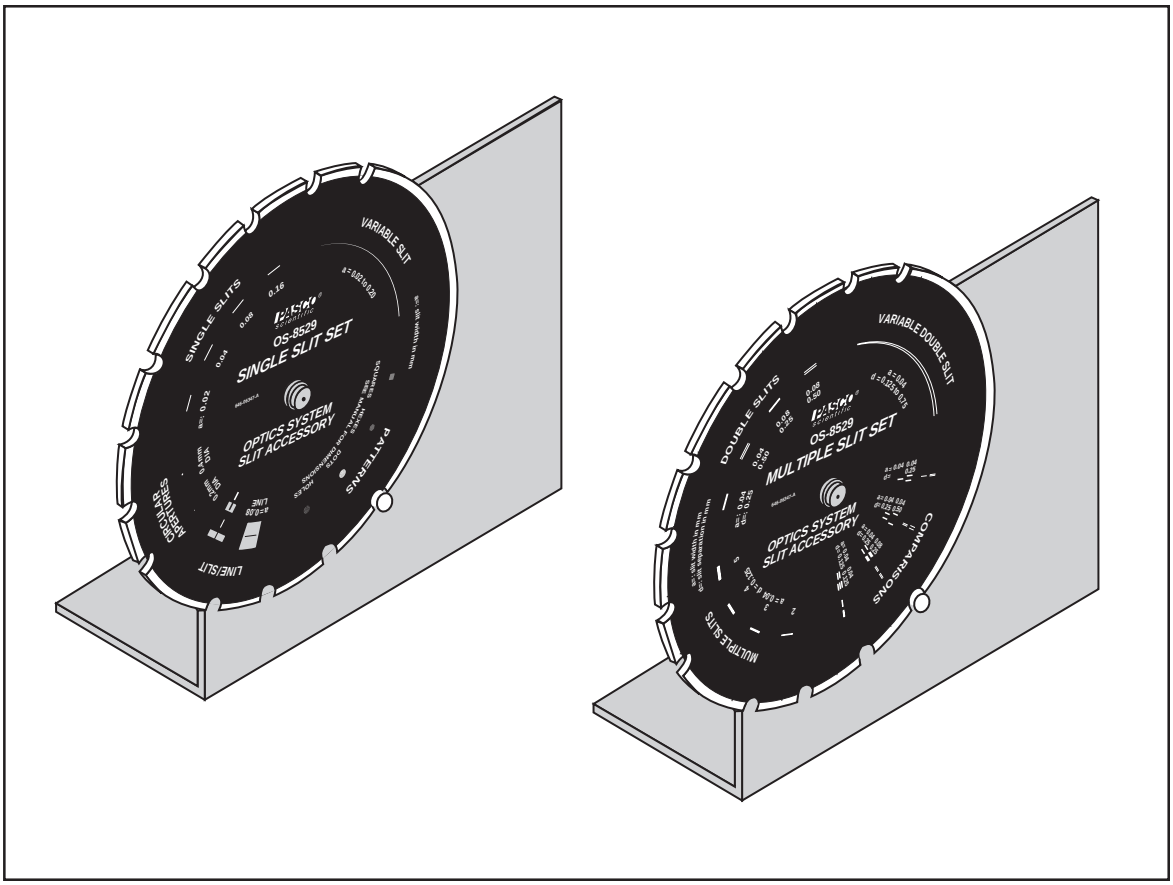
Instruction Manual and Experiment Guide for the PASCO scientific Model OS-8529

012-06348A
5/97

SLIT ACCESSORY

FOR THE INTRODUCTORY AND ADVANCED OPTICS SYSTEMS



$5.00

PASCO scientific ®
10101 Foothills Blvd. • P.O. Box 619011 • Roseville, CA 95678-9011 USA
Phone (916) 786-3800 • FAX (916) 786-8905 • web: www.pasco.com

better ways to teach science

Table of Contents

Section Page

Experiments

Copyright, Warranty, and Equipment Return

Please—Feel free to duplicate this manual subject to the copyright restrictions below.

Copyright Notice

Limited Warranty

PASCO scientific warrants the product to be free from defects in materials and workmanship for a period of one year from the date of shipment to the customer. PASCO will repair or replace, at its option, any part of the product which is deemed to be defective in material or workmanship. The warranty does not cover damage to the product caused by abuse or improper use. Determination of whether a product failure is the result of a manufacturing defect or improper use by the customer shall be made solely by PASCO scientific. Responsibility for the return of equipment for warranty repair belongs to the customer. Equipment must be properly packed to prevent damage and shipped postage or freight prepaid. (Damage caused by improper packing of the equipment for return shipment will not be covered by the warranty.) Shipping costs for returning the equipment after repair will be paid by PASCO scientific.

Credits

Authors: Jon & Ann Hanks
Editor: Sunny Bishop

Equipment Return

Should the product have to be returned to PASCO scientific for any reason, notify PASCO scientific by letter, phone, or fax BEFORE returning the product. Upon notification, the return authorization and shipping instructions will be promptly issued.

➤ **NOTE:** NO EQUIPMENT WILL BE ACCEPTED FOR RETURN WITHOUT AN AUTHORIZATION FROM PASCO.

When returning equipment for repair, the units must be packed properly. Carriers will not accept responsibility for damage caused by improper packing. To be certain the unit will not be damaged in shipment, observe the following rules:

① The shipping carton must be strong enough for the item shipped.

② Make certain there are at least two inches of packing material between any point on the apparatus and the inside walls of the carton.

③ Make certain that the packing material can not shift in the box, or become compressed, thus letting the instrument come in contact with the edge of the shipping carton.

Address: PASCO scientific
10101 Foothills Blvd.
P.O. Box 619011
Roseville, CA 95678-9011

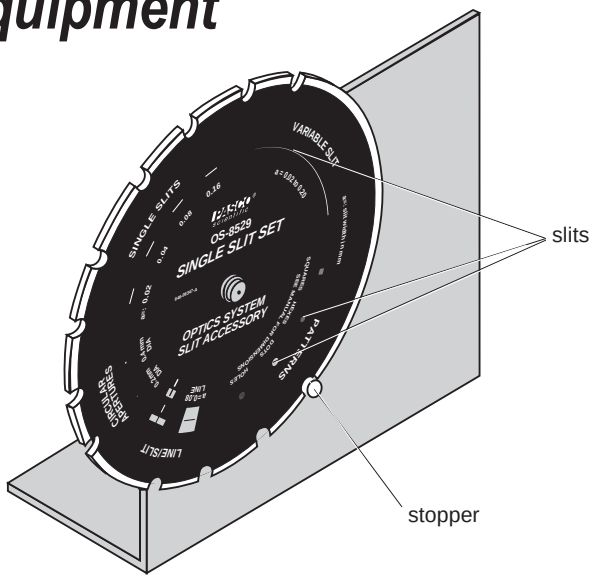
Phone: (916) 786-3800
FAX: (916) 786-8905
email: techsupp@pasco.com

Introduction

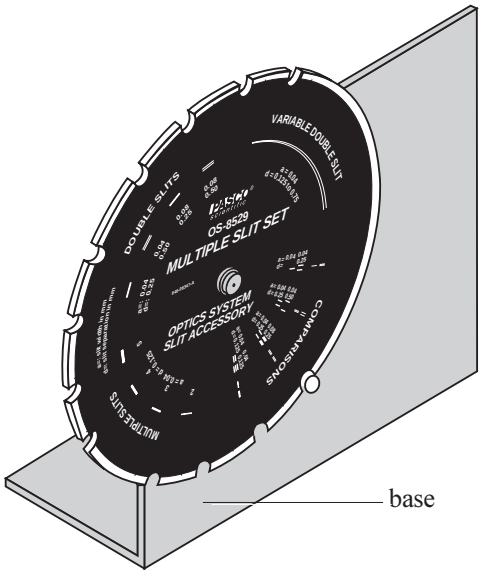
The PASCO OS-8529 Slit Accessory is designed for use with the OS-8528 Diode Laser on the optics bench of the Introductory or Advanced Optics Systems (OS-8500 or OS-9254A). The set of two disks has many different types of slits for diffraction and interference experiments. The special comparison patterns have two different slits spaced close enough together so they can both be illuminated by a single laser beam at the same time, allowing students to compare the two different patterns side-by-side.

➤ ***NOTE: Due to limitations of the photographic process used to produce the slit film, the line and slit may not be exactly the same width.***

Equipment



Single Slit Set

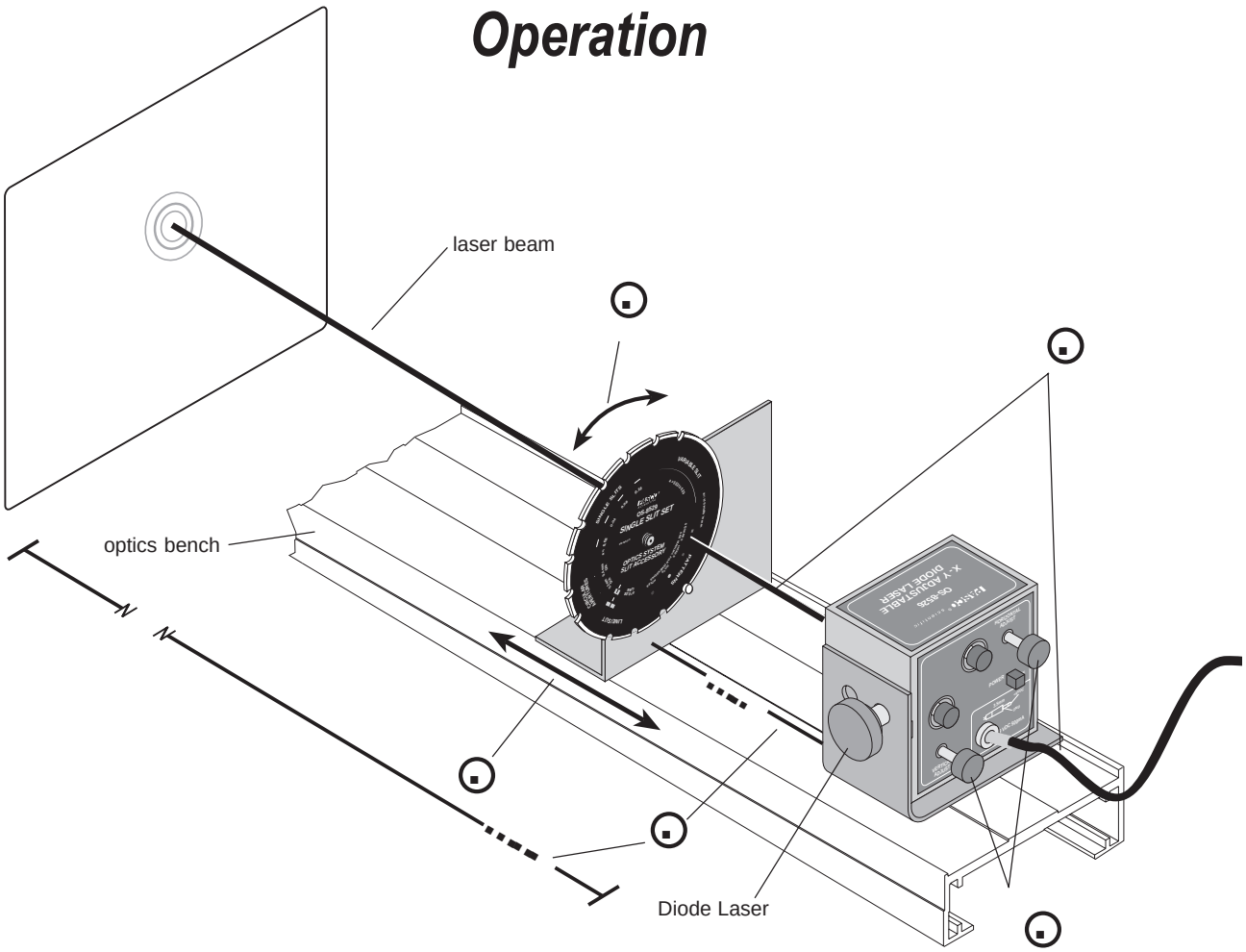


Multiple Slit Set

– 4 single slits (slit widths 0.02, 0.04, 0.08, 0.16 mm)
– 1 variable slit (slit width varies from 0.02 to 0.20 mm)
– 1 square pattern
– 1 hexagonal pattern
– 1 random opaque dot pattern (dot diameter = 0.06 mm)
– 1 random hole pattern (hole diameter = 0.06 mm)
– 1 opaque line of width 0.08 mm
– 1 slit/line comparison, line and slit have similar width (0.04 mm)
– 2 circular apertures (diameters 0.2 mm and 0.4 mm)

– 4 double slits (slit width/separation in mm: 0.04/0.25, 0.04/0.50, 0.08/0.25, 0.08/0.50)
– 1 variable double slit (slit separation varies from 0.125 to 0.75 mm with constant slit width of 0.04 mm)
– 4 comparisons: single/double slit with same slit width (0.04 mm)
– double/double slit with same slit width (0.04 mm), variable separation (0.25 mm – 0.50mm)
– double/double slit with different slit widths (0.04, 0.08 mm), same separation (0.25 mm)
– double/triple slit with same slit width (0.04 mm), same separation (0.125 mm)
– set of 4 multiple slits (2, 3, 4, 5 slits) with same slit width (0.04 mm), same separation (0.125 mm)

Operation



① Place a slit set and the Diode Laser on the magnetic strips of the optics bench about 7 cm apart. Position the optics bench so the Diode Laser is about 1.5 m from a vertical, smooth white projection surface such as a wall, cardboard, etc.

② Align the slit set and the Diode Laser on the optics bench by abutting the edges of the brackets to the side railing of the optics bench.

➤ ***Note: After the initial adjustment, little or no additional adjustment to the alignment of the laser beam with the slit will be required when you change the slit selection.***

③ Select the desired slit by rotating the disk until it clicks into place with the slit at approximately the location of the laser beam on the disk.

④ Adjust the alignment of the laser beam with the slit by moving the laser beam up-and-down and back-and-forth with the vertical and horizontal adjustment screws until the diffraction pattern on the projection surface is most intense.

⑤ Slide the slit set back-and-forth slightly to find the position that results in the most intense diffraction pattern.

Experiment 1: Diffraction from a Single Slit

Materials required:

- optics bench[1]
- Diode Laser (OS-8528)
- Single Slit Set (OS-8529)
- white projection surface
- metric rule
- page 2 of the Slit Accessory manual

[1]From the Introductory or Advanced Optics System (OS-8500 or OS-9254A)

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.

Theory

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

$$a \sin \theta = m\lambda \quad (m = 1, 2, 3, \ldots)$$

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 1.1.

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 minimum and D is the distance from the slit to the screen as shown in Figure 1.1. The diffraction equation can thus be solved for the slit width:

$$a = \frac{m\lambda D}{y} \quad (m = 1, 2, 3, \ldots)$$

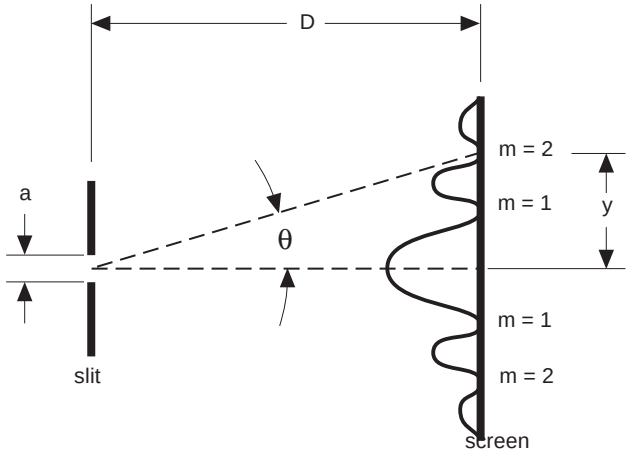


Figure 1.1: Single Slit Diffraction Pattern

Procedure

① Follow the setup procedure on page 2 of the manual using the 0.04 mm slit of the Single Slit Set.

② Measure the distance from the slit to the screen and record.

③ Turn off the room lights and mark the positions of the minima in the diffraction pattern on the projection surface.

④ Turn on the room lights and measure the distance between the first order (m = 1) marks and record this distance in Table 1.1. Also measure the distance between the second order (m = 2) marks and record in Table 1.1.

⑤ Make a sketch of the diffraction pattern to scale.

⑥ Change the slit width to 0.02 mm and 0.08 mm and make sketches to scale of each of these diffraction patterns.

Table 1.1: Data and Results for the 0.04 mm Single Slit

Slit-to-screen distance

(D) = _____

	First Order (m=1)	Second Order (m=2)
Distance between side orders		
Distance from center to side (y)		
Calculated slit width		
% difference		

Analysis

① Divide the distances between side orders by two to get the distances from the center of the pattern to the first and second order minima. Record these values of *y* in Table 1.1.

② Using the average wavelength of the laser (670 nm for the Diode Laser), calculate the slit width twice, once using first order and once using second order. Record the results in Table 1.1.

③ Calculate the percent differences between the experimental slit widths and 0.04 mm. Record in Table 1.1.

Questions

① Does the distance between minima increase or decrease when the slit width is increased?

Experiment 2: Interference from a Double Slit

Materials required:

- optics bench[1]
- Diode Laser (OS-8528)
- Multiple Slit Set (OS-8529)
- white projection surface
- metric rule
- page 2 of the Slit Accessory manual

[1]From the Introductory or Advanced Optics System (OS-8500 or OS-9254A)

Purpose

The purpose of this experiment is to examine the diffraction and interference patterns formed by laser light passing through two slits and verify that the positions of the maxima in the interference pattern match the positions predicted by theory.

Theory

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

$$d \sin\theta = m\lambda \quad (m = 0, 1, 2, 3 \ldots)$$

where d is the slit separation, θ is the angle from the center of the pattern to the mth maximum, 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, . . . counting from the center out). See Figure 2.1.

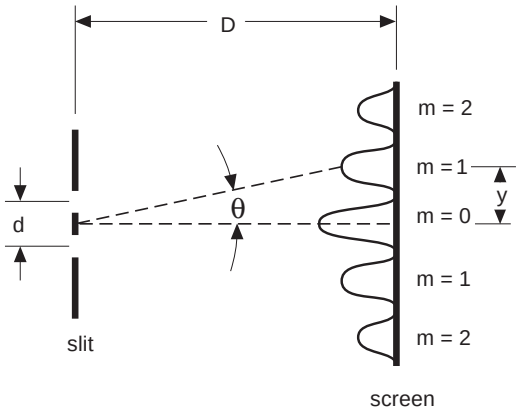


Figure 2.1: Interference Fringes

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

$$\sin\theta \cong \tan\theta$$

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 slits to the screen as shown in Figure 2.1. The interference equation can thus be solved for the slit separation:

$$d = \frac{m\lambda D}{y} \quad (m = 0, 1, 2, 3 \ldots)$$

While the interference fringes are created by the interference of the light coming from the two slits, there is also a diffraction effect occurring at each slit due to single slit diffraction, causing the envelope diagramed in Figure 2.2.

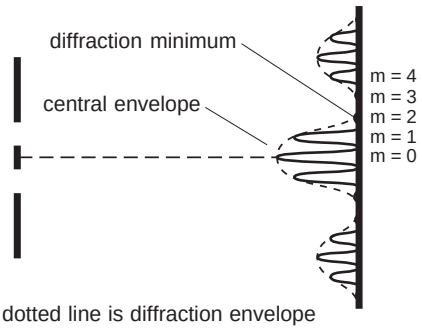


Figure 2.2: Single Slit Diffraction Envelope

Procedure

① Follow the setup procedure on page 2 of the manual using the Multiple Slit Set with the 0.04/0.25 mm (slit width/separation) double slit selected.

② Measure the distance from the slit to the screen and record.

③ Turn off the room lights and mark the positions of the maxima in the interference pattern on the screen.

④ Turn on the room lights and measure the distance between the first order (m = 1) marks and record this distance in Table 2.1. Also measure the distance between the second order (m = 2) marks and record in Table 2.1.

Table 2.1: Data and Results for the 0.04/0.25 mm Double Slit

	First Order (m = 1)	Second Order (m = 2)
Distance between side orders		
Distance from center to side (y)		
Calculated slit separation		
% difference		

Slit-to-screen distance

(D) = _____

Questions

① Does the distance between maxima increase, decrease, or stay the same when the slit separation is increased?

② Does the distance between maxima increase, decrease, or stay the same when the slit width is increased?

③ Does the distance to the first minima in the diffraction envelope increase, decrease, or stay the same when the slit separation is increased?

④ Does the distance to the first minima in the diffraction envelope increase, decrease, or stay the same when the slit width is increased?

⑤ Make a sketch of the interference pattern to scale.

⑥ Change to a new double slit with the same slit width (0.04 mm) but different slit separation (0.50 mm) and make a sketch to scale of this new interference pattern.

⑦ Change to another double slit with a slit width of 0.08 mm and the original slit separation (0.25 mm) and make a sketch to scale of this new interference pattern.

Analysis

① Divide the distances between side orders by two to get the distances from the center of the pattern to the first and second order maxima. Record these values of *y* in Table 2.1.

② Using the average wavelength of the laser (670 nm for the Diode Laser), calculate the slit separation twice, once using first order and once using second order. Record the results in Table 2.1.

③ Calculate the percent differences between the experimental slit separation and 0.25 mm. Record in Table 2.1.

Experiment 3: Comparisons of Diffraction and Interference Patterns

Materials required:

- optics bench[1]
- Diode Laser (OS-8528)
- Single Slit and Multiple Slit Sets (OS-8529)
- white projection surface
- metric rule
- page 2 of the Slit Accessory manual

[1]From the Introductory or Advanced Optics System (OS-8500 or OS-9254A)

Purpose

The purpose of this experiment is to compare the diffraction and interference patterns formed by laser light passing through various combinations of slits.

Theory

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

$$a \sin\theta = m\lambda \quad (m = 1, 2, 3 \ldots)$$

where a is the slit width, θ is the angle from the center of the pattern to the m^{th} 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 3.1.

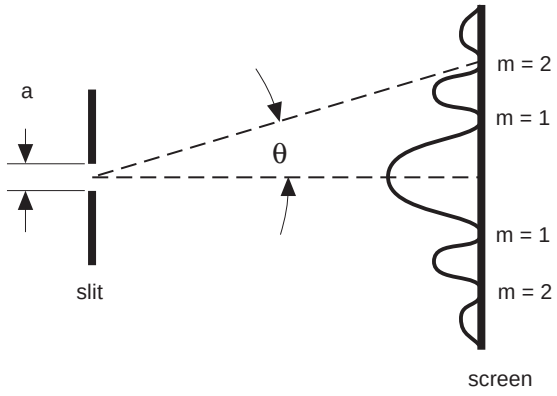


Figure 3.1: Single Slit Diffraction Pattern

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

$$d \sin\theta = m\lambda \quad (m = 0, 1, 2, 3 \ldots)$$

where d is the slit separation, θ is the angle from the center of the pattern to the m^{th} maximum, 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, . . . counting from the center out). See Figure 3.2.

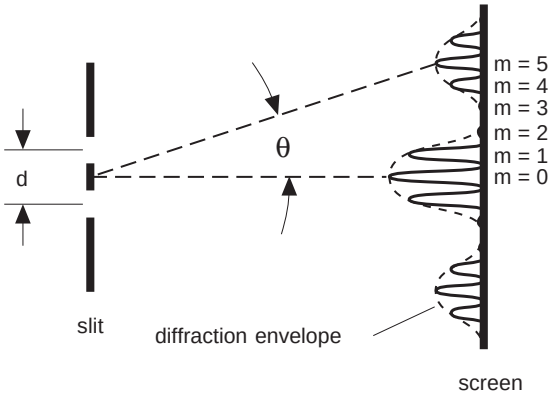


Figure 3.2: Interference Fringes

Procedure

① Follow the setup procedure on page 2 of the manual using the Multiple Slit Set with the single-double slit comparison selected.

② Sketch the two side-by-side patterns roughly to scale.

③ Rotate the slit disk to the next comparison set (2 double slits with the same slit width but different slit separations). Sketch the two side-by-side patterns roughly to scale.

④ Rotate the slit disk to the next comparison set (2 double slits with the same slit separation but different slit widths). Sketch the two side-by-side patterns roughly to scale.

⑤ Rotate the slit disk to the next comparison set (double slits/triple slits with the same slit separation and same slit widths). Sketch the two side-by-side patterns roughly to scale.

⑥ Replace the Multiple Slit Set with the Single Slit Set. Select the line/slit comparison. Sketch the two side-by-side patterns roughly to scale.

⑦ Select the dot pattern, and sketch the resulting diffraction pattern roughly to scale.

⑧ Select the hole pattern, and sketch the resulting diffraction pattern roughly to scale.

Questions

① What are the similarities and differences between the single slit and the double slit?

② How does the double slit pattern change when the slit separation is increased?

③ How does the double slit pattern change when the slit width is increased?

④ What differences are there between a double slit pattern and a triple slit pattern?

Technical Support

Feedback

If you have any comments about the product or manual, please let us know. If you have any suggestions on alternate experiments or find a problem in the manual, please tell us. PASCO appreciates any customer feedback. Your input helps us evaluate and improve our product.

To Reach PASCO

For technical support, call us at 1-800-772-8700 (toll-free within the U.S.) or (916) 786-3800.

fax: (916) 786-3292

e-mail: techsupp@pasco.com

web: www.pasco.com

Contacting Technical Support

Before you call the PASCO Technical Support staff, it would be helpful to prepare the following information:

➤ If your problem is with the PASCO apparatus, note:

- Title and model number (usually listed on the label);
- Approximate age of apparatus;
- A detailed description of the problem/sequence of events (in case you can't call PASCO right away, you won't lose valuable data);
- If possible, have the apparatus within reach when calling to facilitate description of individual parts.

➤ If your problem relates to the instruction manual, note:

- Part number and revision (listed by month and year on the front cover);
- Have the manual at hand to discuss your questions.