

Interference and Diffraction

Name _____ ID _____ TA _____

Partners _____

Date _____ Section _____

Do not look directly into the laser beam. Set up your experiment so that the laser beam is NOT at eye level.

1. Wavelength determination from the interference maxima of double slits:

To calculate the wavelength, you will use the following formula:

$$\lambda = \frac{d \sin \theta}{n}, \quad \theta = \tan^{-1} \left(\frac{y_n}{D} \right)$$

where λ is the wavelength of the laser beam, d is the distance between slits, D is the distance from the slit to the screen, y_n is the distance of the n-th intensity maximum from the central maximum, and n is the order.

$D =$ _____ (feet) $\times 0.3048 +$ _____ (inches) $\times 0.0254 \Rightarrow$ _____ (meters)

➤ **Calculations to get d (distance between slits):**

(Pick out only double slits, which are indicated as 2 at the top.)

★ <sw=slit width; ds=dark space> ★

double slit 1: The middle values $\times 4.393 \times 10^{-5}(\text{m}) \rightarrow sw_1 =$ _____ (m)

The bottom values $\times 4.393 \times 10^{-5}(\text{m}) \rightarrow ds_1 =$ _____ (m)

double slit 2: The middle values $\times 4.393 \times 10^{-5}(\text{m}) \rightarrow sw_2 =$ _____ (m)

The bottom values $\times 4.393 \times 10^{-5}(\text{m}) \rightarrow ds_2 =$ _____ (m)

★ <distance between slits> ★

$d_1 = sw_1 + ds_1 =$ _____ (m); $d_2 = sw_2 + ds_2 =$ _____ (m)

n	$d_1 =$ _____ (m)					$d_2 =$ _____ (m)				
	left y_n	right y_n	Ave. y_n (left+right)/2	θ (= $\tan^{-1}y_n/D$)	λ	left y_n	right y_n	Ave. y_n (left+right)/2	θ (= $\tan^{-1}y_n/D$)	λ
1										
2										
3										
4										
	Average value of $\lambda \Rightarrow$					Average value of $\lambda \Rightarrow$				

How well do your values agree and with the expected value of $6.328 \times 10^{-7} \text{ m}$?

2. Wavelength determination from the interference minima of single slits:

To calculate the wavelength, you will use the following formula:

$$\lambda = \frac{W \sin \theta}{m}, \quad \theta = \tan^{-1} \left(\frac{y_m}{D} \right)$$

where λ is the wavelength of the laser beam, W is the slit width, D is the distance from the slit to the screen, y_m is the distance of the m -th dark fringe from the central maximum, and m is the order.

$$D = \text{_____ (feet)} \times 0.3048 + \text{_____ (inches)} \times 0.0254 \Rightarrow \text{_____ (meters)}$$

➤ Calculations to get W (slit width):

(Pick out only single slit, which are indicated as 1 at the top.)

★ <sw=slit width> ★

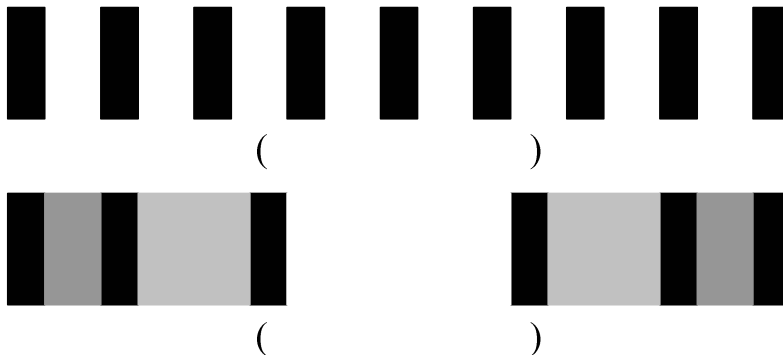
single slit 1: The middle value $\times 4.393 \times 10^{-5}(\text{m}) \rightarrow sw_3 = W_1$ _____ (m)

single slit 2: The middle value $\times 4.393 \times 10^{-5}(\text{m}) \rightarrow sw_4 = W_2$ _____ (m)

m	$W_1 = \text{_____ (m)}$					$W_2 = \text{_____ (m)}$				
	left y_m	right y_m	Ave. y_m (left+right)/2	θ ($=\tan^{-1}y_m/D$)	λ	left y_m	right y_m	Ave. y_m (left+right)/2	θ ($=\tan^{-1}y_m/D$)	λ
1										
2										
3										
4										
	Average value of $\lambda \Rightarrow$					Average value of $\lambda \Rightarrow$				

How well do your values agree and with the expected value of $6.328 \times 10^{-7} \text{ m}$?

Question: Label which is the image of single or double slit. (Note that the dark part is a dark fringe.)



Lab Procedure for Interference and Diffraction

You are only allowed to use ‘meters’ as length units. Otherwise, you will not be able to compare results with the reference value.

1. Wavelength determination from the interference maxima of double slits

- **First, you should note the unit conversions to complete this lab properly.**
From ‘mm’ to ‘m’, multiply it by 0.001. e.g. 3.4 mm → 0.0034 m
From ‘feet’ to ‘m’, multiply it by 0.3048. e.g. 6.9 feet → 2.1031 m
From ‘inches’ to ‘m’, multiply it by 0.0254 e.g. 4.5 inches → 0.1143 m
- **As the TA will show, pick out two kinds of double slits from the “Cornell Interference and Diffraction Slitfilm Demonstrator.”**
From the reference paper, you will calculate a distance between slits, d_1 and d_2 . Just follow the data sheet.
- **Illuminate one of the double slits with the laser beam.**
You will get the diffraction pattern on the screen (paper).
- **Measure the distance from the Slitfilm to the screen.**
This value will be D . The measuring instrument that you will use is only calibrated in feet, so don’t forget to convert it to meters.
- **Measure the left and right distances from the center maximum to the intensity maxima.**
These will be left y_n and right y_n . Try to get up to y_4 . Don’t forget to convert the units into meters.
- **Calculate the average y_n from left y_n and right y_n .**
Average $y_n = (\text{left } y_n + \text{right } y_n) \div 2$
- **Calculate each wavelength, λ . → Plug d , θ , D , n , and ave. y_n into the given formula.**
- **Do the same thing for the other double slits.**
- **At last, calculate the average wavelength. Then compare it with the reference value of the helium-neon laser. → 6.328×10^{-7} m (632.8 nm)**
Even if you used different types of slits, this result should be the same within some deviation.

2. Wavelength determination from the interference minima of single slits

- **The procedure is exactly the same as above. However, you measure y_m from the central maximum to a dark fringe.**

Lab report

For the feedback, feel free to discuss what you learned; what you didn’t understand.

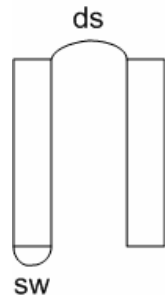
Cornell Interference and Diffraction Slitfilm Demonstrator

(The National Press, Palo, Alto, CA)

The following figure expresses the parameters of a slit pattern. Each rectangle has several kinds of slit-patterns, such as single, double, and multiple slits. This explains the location of certain slit patterns on the Slitfilm, and variables like the slit width, etc.

1. **Each slit film has basically three variables.**

- Top → number of the slits
- Middle → slit width (sw)
- Bottom → distance of dark space (ds)

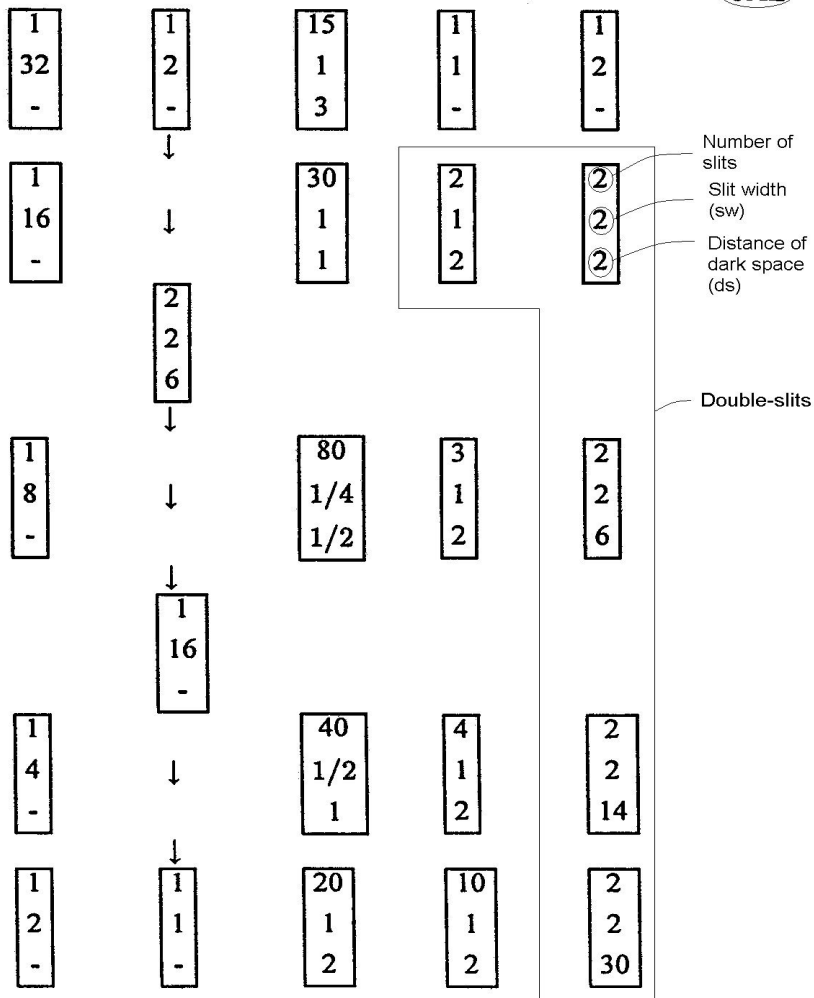


Multiply by the second number by 4.393×10^{-5} m to obtain the actual slit width

2. **The unit of the variables is called "point" based on a printer's "point size."**

1 point = 4.393×10^{-5} m

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Example:

Suppose you want to illuminate the following slit. Find the distance between slits.

2
4
8

Solution:

From the top number, there are two slits. From the second number, the slit width, "sw" is 4 points. Multiplying by 4.393×10^{-5} , you have 1.7572×10^{-4} m. From the bottom number, the distance of dark space is 8 points. Then, calculate $8 \times 4.393 \times 10^{-5} = 3.5144 \times 10^{-4}$ m. Therefore, the slit width, d , will be $sw + ds = 1.7572 \times 10^{-4} + 3.5144 \times 10^{-4} = \underline{\underline{5.2716 \times 10^{-4} \text{ m}}}$.