Interference and Diffraction of Light

TA's signature allowing you to take the quiz or leave ____________

Your Name ______________________________

Partners' Names ______________________________

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Obtained reasonable experimental results?	yes	☐
Answered questions?	yes	☐
Cleaned your table?	yes	☐

Warning

- **Do not look directly into the laser beam. Set up your experiment so the laser beams in NOT at eye level.**
- **Do not scratch the wall with a pen / pencil. Use a piece of paper to record the data.**

Introduction

In practice, the property of light can be described as ray optics illustrated in the previous labs, Geometrical Optics and Refractive Index" and "Thin Lenses and its Equations." The ray optics explains that the light ray goes through straight to focus an image associated with most of daily life phenomena, such as telescopes, microscopes, etc. However, in a microscopic way, light has a different property. Light is one of the electromagnetic waves, which is described by frequencies or wavelengths. In a word, light also has a wave character.

Young's double slits experiment is a famous test to show the wave property of light which is based on diffraction and interference. This cannot be explained by ray optics because only two slits gives multiple fringes on a screen. According to this particular experiment, the wavelength of the light can be obtained as follows:

$$\lambda = \frac{d \sin\theta}{n}$$

where d is the distance between slits, n is the order of light spot, and θ is the angle from the center to the light spot. With a single slit, one can discuss this in the same way, but the theory is not straightforward. The eventual formula appears to be similar to the double slits:

$$\lambda = \frac{W \sin\theta}{m}$$

where W is the slit width, m is the order, and θ is the angle as stated above. However, this is for the dark fringes.

Objectives:

- To learn the wave property of light
- To find the wavelength of laser with double and single slits based upon the theory

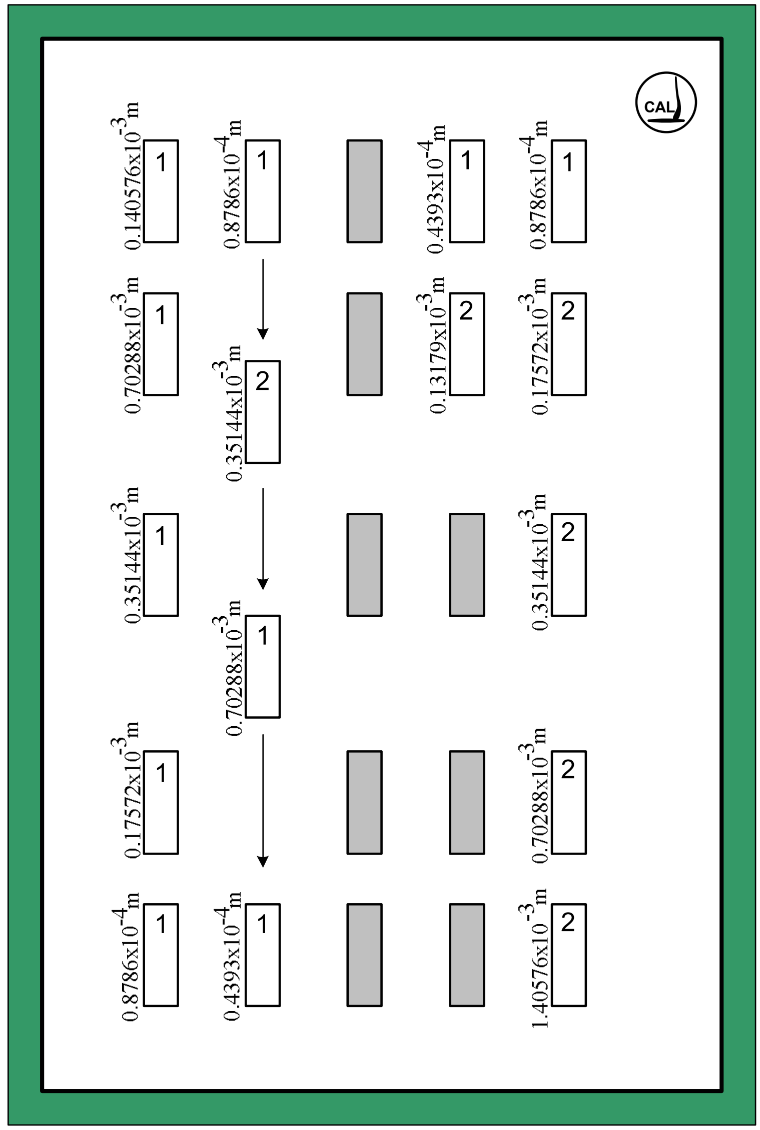
- **Preparation**

The Cornell Interference and Diffraction Slitfilm Demonstrator is used in this lab. It contains several slits including single, double, and multiple slits.

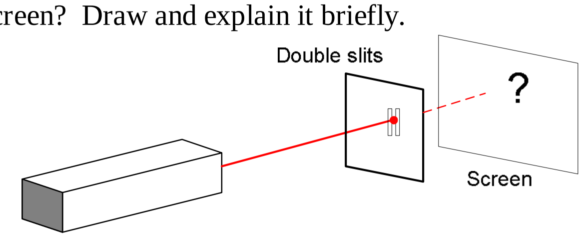
With CAL marked in the upper right corner, each slit is placed as shown. The numbers 1 and 2 indicate single and double slits, respectively. The values, such as 0.8786×10^{-4} m, are the distance between slits, d .

The series of slits along with arrows are the continuous slits. Do not use them unless you know exactly where you illuminate.

The shaded ones are multiple slits which are not used in this lab.



What do most people believe will happen (misconceptions) when you shine a laser beam on a double slit? What is the possible shape or pattern on the screen? Draw and explain it briefly.



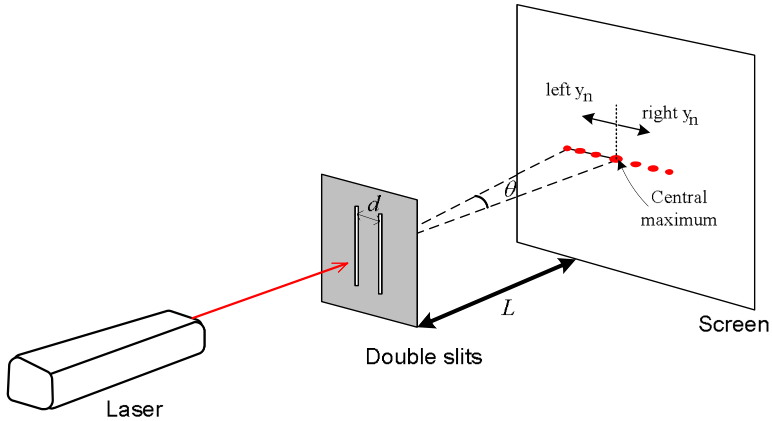
1. Wavelength determination from the interference maxima of double slits:

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

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

where λ is the wavelength of the laser beam, d is the distance between slits, L 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.

Warning: the tape measurer may **CUT** your finger. Exercise caution to handle it.



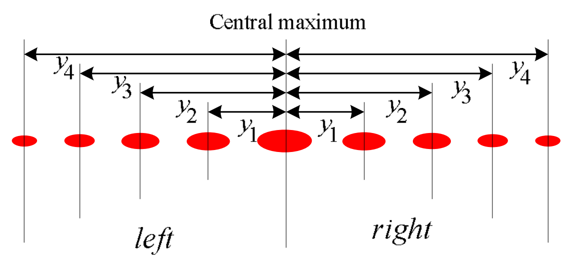
Conversion formulas if needed	
From 'mm' to 'm', multiply it by 0.001.	e.g. 3.4 mm → 0.0034 m
From 'cm' to 'm', multiply it by 0.010.	e.g. 5.6 cm → 0.056 m
From 'feet' to 'm', multiply it by 0.3048.	e.g. 6.9 feet → 2.1031 m
From 'inches' to 'm', multiply it by 0.0254	e.g. 4.5 inches → 0.1143 m

L = ____ (meters)

- Obtain the distance between slits, d :

(See the preparation.)

Find the **center** of each bright spot to measure the y_n. ⇒



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

How well do your values agree and with the expected value of 6.328×10^{-7} m (or 632.8 nm)? (**Helium-Neon Laser**)

$$\text{Percent error} = \frac{|\lambda_{accepted} - \lambda_{measured}|}{\lambda_{accepted}} \times 100\% = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

✍ **Insight:** If you use an approximation, $\sin\theta \approx \tan\theta$ when the angle is very small, you have $\sin\theta \approx \frac{y}{L}$. Thus, the above formula can be $\lambda = \frac{y_n d}{nL}$. Take the best value from the above data and calculate with this formula. Compare how close this with the above result (Show the work):

____

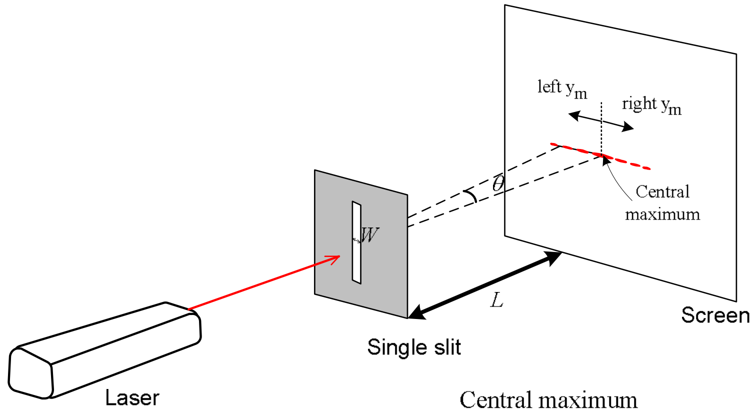
Have the initial of your instructor after completing this part. **Otherwise, points will be deducted.**

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

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

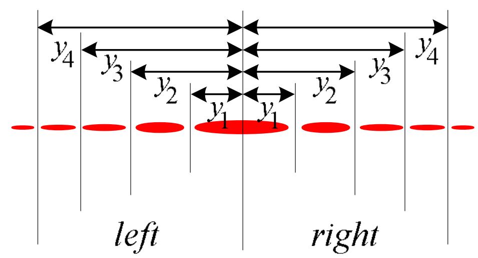
$$\lambda = \frac{W \sin\theta}{m}, \quad \text{where } \theta = \tan^{-1}\left(\frac{y_m}{L}\right)$$

where λ is the wavelength of the laser beam, W is the slit width, L 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.



Measurement of distance between slits and screen:

L = ____ (meters)



➢ Obtain the slit width, W :

(Choose a single slit, which are indicated as 1 in the rectangular.)

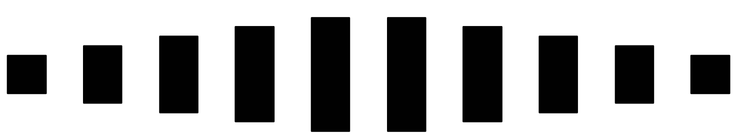
Find from the **center** of central maximum to each center of the dark fringe to measure the y_n. ⇑

n	W =____________(m)				
	left y_m	right y_m	Ave. y_m (left+ right)/2	θ (=$\tan^{-1}y_m/L$)	λ
1					
2					
3					
4					
	Average value of $\lambda \Rightarrow$				

How well do your values agree and with the expected value of 6.328×10^{-7} m (or 632.8 nm)? (**Helium-Neon Laser**)

$$\text{Percent error} = \frac{|\lambda_{accepted} - \lambda_{measured}|}{\lambda_{accepted}} \times 100\% = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

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



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