Young's Double Slit Experiment

(Physics 7, Experiment #8)

Equipment: (All pieces made by Pasco)

1.2 m Optics Track
Multiple Slit Wheel (Includes 4 Double Slits)
Diode Red Laser
Linear Translator (if available)
Light Sensor (if available)
Aperture Bracket (if available)
Screen
Optics Calipers (if available)

Purpose:

In the late 1600's Christian Huygens first proposed that light behaves like a wave. Although this model of light could be used to explain many results of geometric optics, it wasn't until 1801 when Thomas Young first performed his double slit experiment that light was experimentally confirmed to behave like a wave. In this experiment you will perform the famous double slit experiment and then observe and measure the resulting interference patterns.

Principles:

When monochromatic, coherent light is passed through a pair of closely spaced slits an interference pattern is observed on a screen some distance from the slits. The interference pattern is the result of the alternating constructive and destructive interference of the waves of light emitted by each slit. As can be seen in Figure 1, the two light rays emerging from the slits travel a different distance to reach the screen. The path difference is $\delta = d \sin \theta$ (Eq. 1). If this path difference is an integer multiple of the wavelength of light, then the two waves will constructively interfere when they reach the screen and a bright spot will be observed. On the other hand if the path difference is off by ± 0.5, ± 1.5, ± 2.5… wavelengths, then destructive interference will result and a dark fringe will be seen. These results can be summarized in equation form:

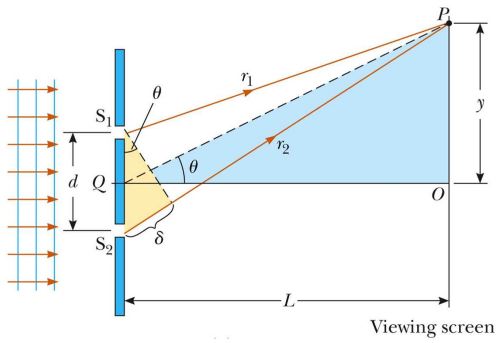


Figure 1: Layout of the double slit experiment showing how δ, d, θ, y, L are defined.

$d \sin \theta_{bright} = m \lambda$ (m = 0, 1, 2, …) constructive interference (Eq. 2)

$d \sin \theta_{dark} = (m + ½) \lambda$ (m = 0, 1, 2, …) destructive interference (Eq. 3)

As can also be seen from Figure 1, the point, P, on the screen is a distance y from point O, and by geometry,

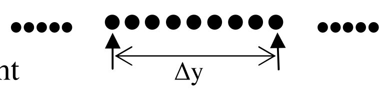
$\tan \theta = y/L$ (Eq. 4)

Since L is quite large with respect to y, then θ becomes a very small angle and we can use the small angle approximation: $\tan \theta \approx \sin \theta \approx \theta$ in the above formulas.

Procedures:

a. The set up of the equipment listed above is fairly straightforward and will be demonstrated in class.

b. After setting up the equipment, rotate the multiple slit wheel so that the diode laser light is passing through one of the double slits and an interference pattern is produced on the screen. (Note: You will see an interference pattern within a diffraction envelope. For this experiment you can ignore the diffraction envelope and focus on measuring the interference pattern.)



c. Use the optics calipers to measure the distance from the right most bright spot in the central set of spots, to the left most bright spot in the central set. Also count the order number, m, for these two bright spots. (Hint: One m value should be the negative of the other m value.) Record the measurements in the data table.

d. Repeat step c for each set of double slits on the disk.

e. If there is a green laser available, repeat steps c and d using the green laser.

Double Slit Experiment Data Table

λ (nm) (shown on laser)	d (mm) (shown on disk)	L (m)	Δy (mm) ($\Delta y = y_{right} - y_{left}$)	m_{right}	m_{left}	Δm ($\Delta m = m_{right} - m_{left}$)	$\Delta y/\Delta m$ (mm) (experimental)	$\Delta y/\Delta m$ (mm) (theoretical)	% error

Lab Report and Calculations:

The calculations for this experiment should be straightforward. Start by using equations 2 and 4 in the principle's section to find a formula for y in terms of λ, d, L and m. Since y and m are the variables, you can write this formula with Δy replacing y, and Δm replacing m. Then solve for $\Delta y/\Delta m$ in terms of λ, d and L. Use this formula to find the theoretical values of $\Delta y/\Delta m$ for each double slit measurement you made and enter the theoretical values in the table above. Lastly, for each case, calculate a percentage error between the experimental value of $\Delta y/\Delta m$ and the theoretical value of $\Delta y/\Delta m$.

As usual write a conclusion section indicating what you observed in the experiment and what might be some sources of error.

Name of Student: ____

Date Performed: ____

Instructor's Initial: ______________________________________