Double-Slit Interference

1. **Objectives**. The objective of this laboratory is to verify the double-slit interference relationship.

2. **Theory**.

a. When monochromatic, coherent light is incident upon a double slit, a pattern of constructive and destructive interference is produced. Figure 1 shows the geometry of the double-slit interference experiment.

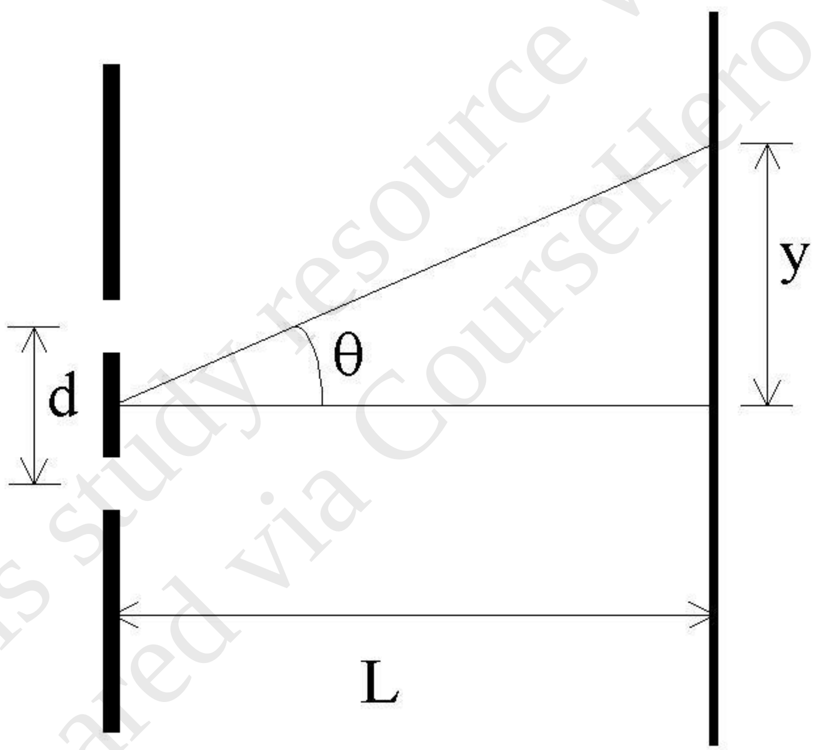

Figure 1. Double-slit interference geometry.

b. The double-slit relationship for constructive interference maxima is given by

$$m \lambda = d \sin\theta$$

with m = 0, 1, 2, 3, ...

where

m	is the order of the interference maximum,
λ	is the wavelength of the light incident on the double slit,
d	is the spacing between the slits and
θ	is the angle defined by

$$\theta = tan^{-1} (y / L)$$

The small angle approximation allows

$$sin\theta = tan\theta$$

Thus, the double-slit relationship can be written as

$$m \lambda = d y / L$$

This relationship can be written in an alternate form for the purposes of this experiment:

$$y = m \lambda L / d$$

c. To verify this relationship three experiments will be performed:

1) y as a function of m. The separation distance between the central maximum (m = 0) and other maxima is directly proportional to m, the order of the interference maximum. In this experiment the values of λ, L and d will be held constant, while measurements of the separation distance between the central maximum (m = 0) and other maxima are made.

2) y as a function of L. The separation distance between the central maximum (m = 0) and any particular maxima is directly proportional to L, the distance between the double-slit and the interference pattern. In this experiment the values of λ, m and d will be held constant, while measurements of the separation distance between the central maximum (m = 0) and another maxima are made as the distance between the double-slits and interference pattern is varied.

3) y as a function of d. The separation distance between the central maximum (m = 0) and any particular maxima is inversely proportional to the spacing between the double slits. In this experiment the values of λ, m and L will be held constant, while measurements of the separation distance between the central maximum (m = 0) and another maxima are made as the distance between the double slits is varied.

3. **Apparatus and experimental procedures.**

a. Equipment.

1) Optical bench with metric scale.

2) Set of double slits.

3) Diode laser.

4) Meter stick and ruler.

5) Paper.

6) Tape.

7) Flashlight.

b. Experimental setup. A figure for the experimental setup will be provided by the student.

c. Capabilities. Capabilities of the equipment items listed in paragraph 3a will be provided by the student.

d. Procedures. Detailed instructions are provided in paragraph 4 below.

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4. **Requirements***.*

a. In the laboratory.

1) Your instructor will introduce you to the equipment to be used in the experiment.

2) Align the laser beam on the 0.50 mm double slit and produce an interference pattern on a piece of paper taped to a wall of the lab room at a distance of approximately six (6) meters.

3) Mark the position of the central maximum on the paper and the m = 1 to m = 6 maxima on both sides of the central maximum. Measure the distance between the same numbered maxima on both sides of the central maximum (this distance is 2y for each value of m).

4) Again using the 0.50 mm slit spacing measure the distance between the m = 3 maxima on each side of the central maximum for five different distances between the slits and the interference pattern on the wall (L). Use distances between three and seven meters.

5) Using a fixed value of the distance from the slits to the interference pattern (L) of approximately six meters, measure the distance between the m = 3 maxima on each side of the central maximum for slit widths of 0.125 mm, 0.25 mm and 0.50 mm.

6) Record your data in the tables provided in Annex A.

b. After the laboratory. The items listed below will be turned in at the beginning of the next laboratory period. A complete laboratory report is **not** required for this experiment.

Para 3. Apparatus and experimental procedures.

1) Provide a figure of the experimental apparatus (para 3b).

2) Provide descriptions of the capabilities of equipment used in the experiment (para 3c).

Para 4. Data. Data tables are included at Annex A for recording measurements taken in the laboratory. A copy of these tables must be included with the lab report. Provide the items listed below in your report in the form a Microsoft Excel™ spreadsheet showing data and calculations. <u>The spreadsheet will include:</u>

1) Experiment 1:

a) A list of the values of the fixed parameters: L and d.

b) A table of 2y versus m for m = 1 to m = 6.

c) A graph of y versus m. Include a regression (trend) line on the graph.

2) Experiment 2:

a) A list of the values of the fixed parameters: m and d.

b) A table of 2y versus L for five values of L.

c) A graph of y versus L. Include a regression (trend) line on the graph.

3) Experiment 3:

a) A list of the values of the fixed parameters: m and L.

b) A table of 2y versus d for three values of d.

c) A graph of y versus 1/d. Include a regression (trend) line on the graph.

5. Results and Conclusions.

a. Results.

1) Discuss the variation in y as a function of m.

2) Discuss the variation in y as a function of L.

3) Discuss the variation in y as a function of d.

b. Conclusions.

Provide a description of the sources error in the laboratory.

Annex A
Data

1. Experiment 1.

L = ______________________ *m*

d = ______________________ *mm*

m	2y (*cm*)
1	
2	
3	
4	
5	
6	

2. Experiment 2.

m = __________3__________

d = ______________________ mm

L (*m*)	2y (*cm*)

3. Experiment 3.

m = ___________3___________

L = _______________________ m

d (mm)	2y (cm)
0.125	
0.25	
0.50	