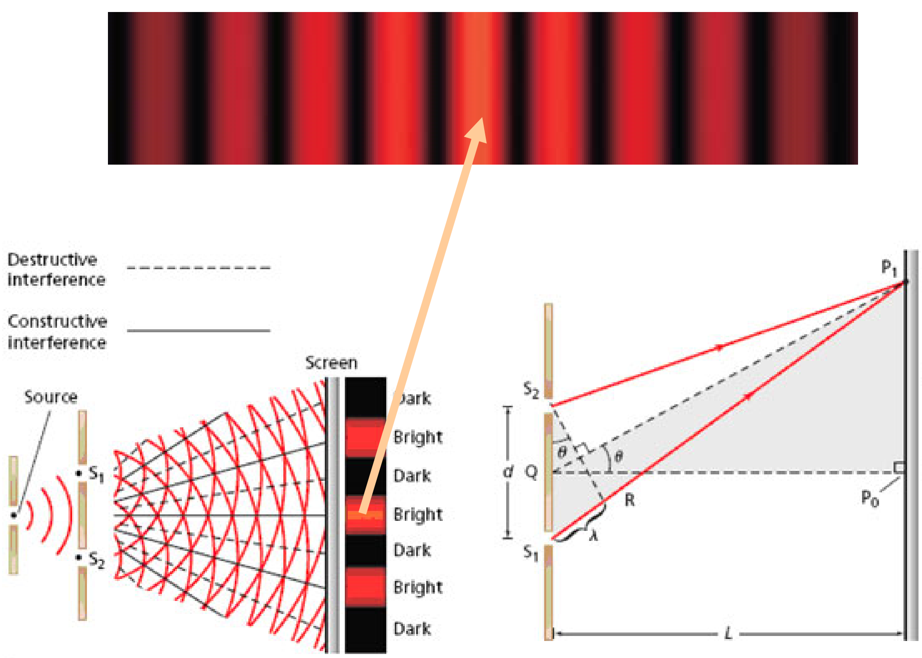
MND Physics

Double-Slit Interference

As Thomas Young demonstrated in 1801, light falling on two closely spaced slits passes through the slits and diffracts. The spreading light from each slit overlaps and produces an interference pattern on a screen. Since interference is a wave behavior, this experiment proves that light has a wave nature.

The interference pattern that forms consists of alternating bright and dark bands; a bright band appears in the center of the screen with alternating dark and bright bands (wide lines) appearing on either side of the central band:



In this lab, you will measure the distance x between the first, second and third order bright band and the central maximum. Then using the following formula, you will calculate the wavelength of the laser light:

$$\lambda = (x\,d) / (m\,L)$$

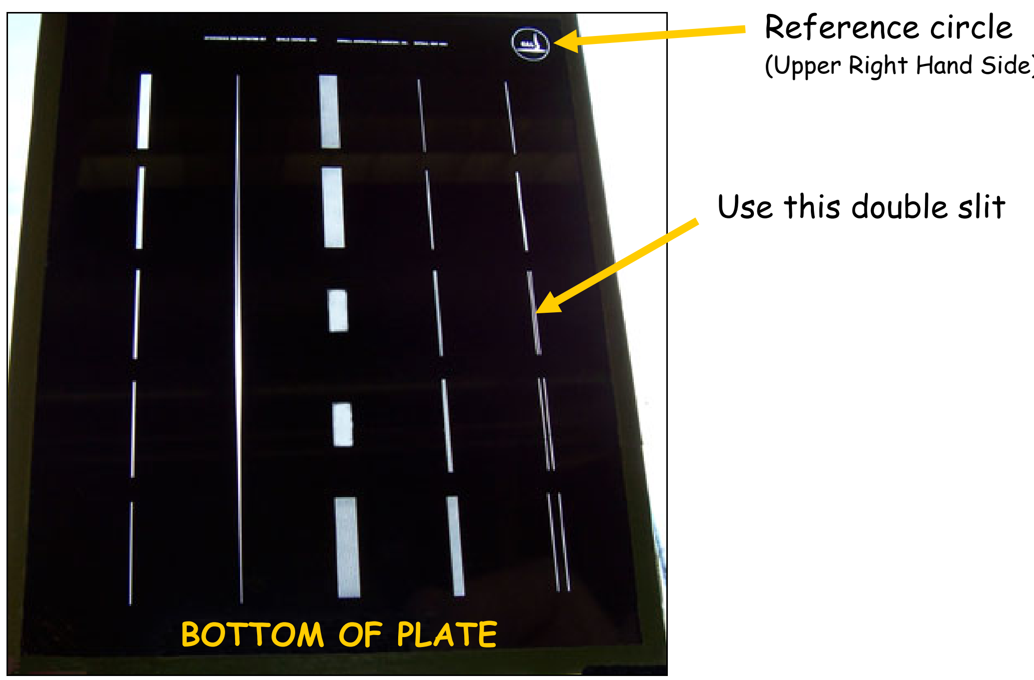
where m = 1 **(first order)**, 2 **(second order)** and 3 **(third order)**.

EQUIPMENT:

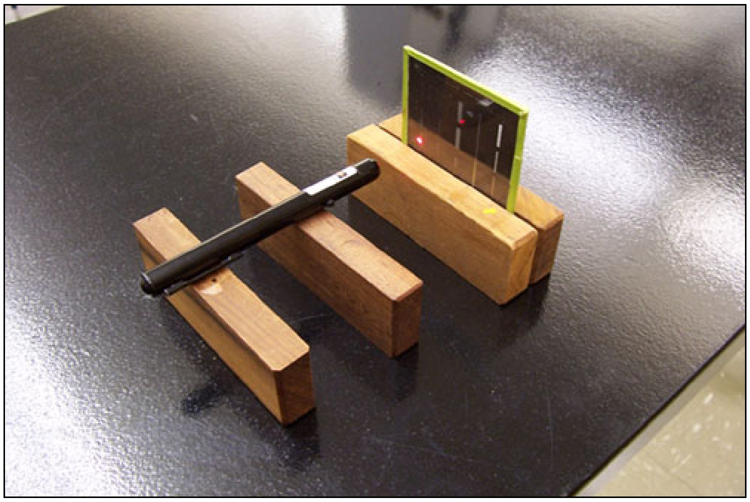
Double-slit glass plate, laser pointer with batteries, holders, meter stick, metric ruler, screen board and 8 ½ x 11" plain white paper, masking tape, metric tape measure.

PROCEDURE:

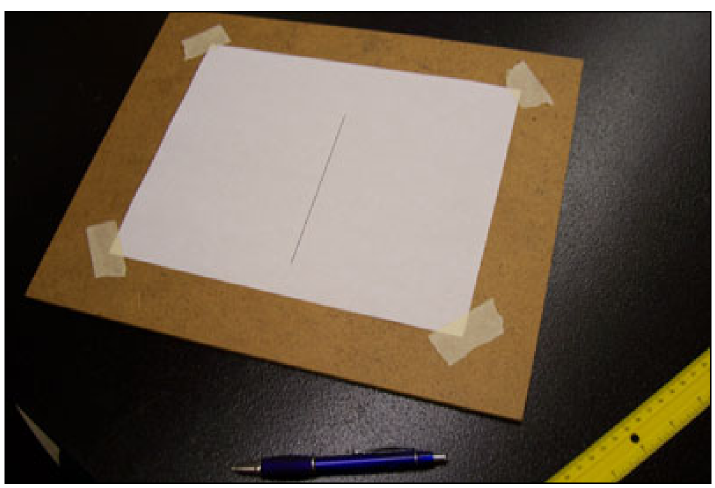
1. Locate the reference circle on your glass plate; it's in the upper right hand side of the plate. You will be using the double slit that is 0.350mm wide; it's the third slit down on the far right hand side as shown here:



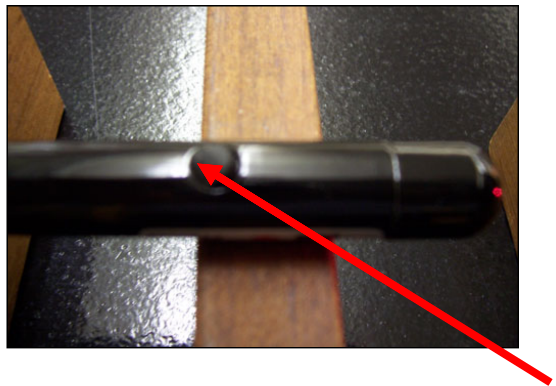
2. Place the laser pointer on two wood block holders with the double slit plate in front of the laser sandwiched between two more blocks as shown. Make sure the beam is aimed such that it clearly travels through the correct double-slit opening.



3. Mount a piece of plain white paper on the screen boards provided. This will be used as your projection screen. Place a vertical line in the middle of the paper.

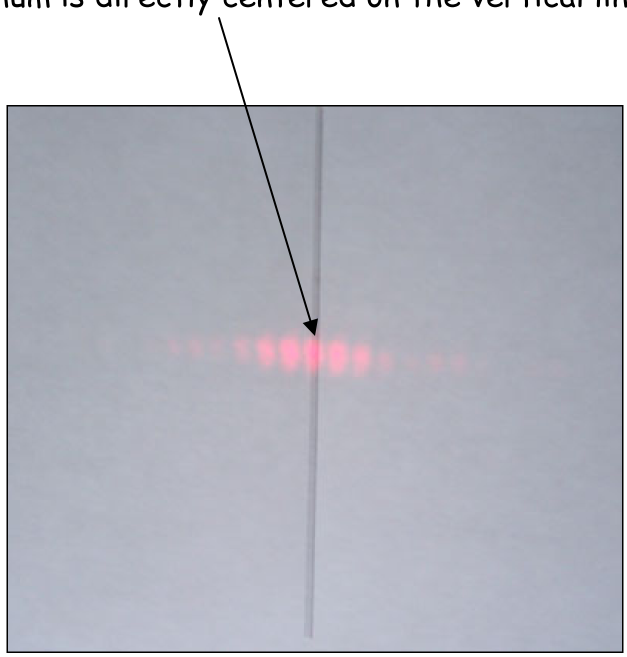


4. Measure <u>at least</u> 3.0 m (longer would be better) from your glass plate to the screen position; fix both the glass plate and the screen in place and record this distance. A metric tape measure is available for this measurement.

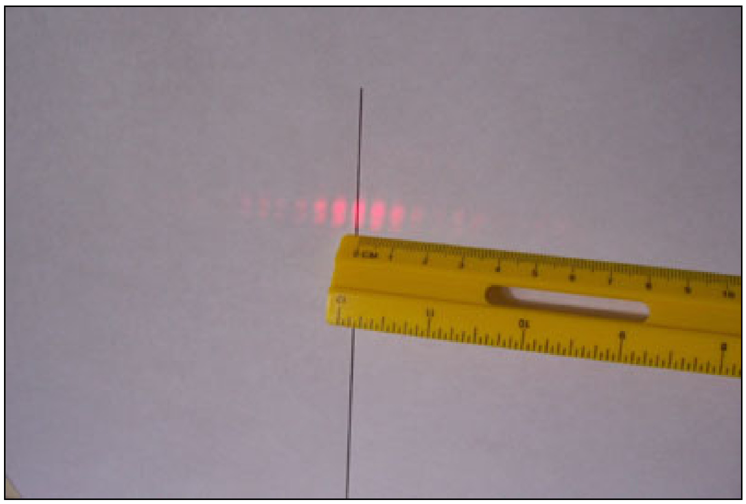


5. Press and hold the switch on the laser pointer. Carefully slide the rubber button switch backwards so that part of the switch is under the black outer tube; in this mode, the laser will remain in the "on" position. With the beam traveling through the double slits, you will see an interference pattern. **CAUTION:** NEVER LOOK DIRECTLY INTO THE LASER!

6. Carefully move the screen left or right so that the central bright band maximum is directly centered on the vertical line.



7. Using a metric ruler, measure the distance from the central maximum to the first order band. Record this value in the data table. Repeat this process for the second order band, making sure to measure the distance between the central band and the second order band. Repeat the process again measuring the distance between the central band and the third order band. Record all values in the data table.



8. Calculate the wavelength of light using your data.

9. Calculate your error using the known value of the wavelength of the laser light (the known value is printed on the laser pointer).

DATA:

	Lab Data	Data: converted to meters
Slit Separation (mm)	0.350 mm	m
Length "L" Distance from glass plate to screen (m)	m	m
Distance x_1 1^{st} Band to Central Maximum (mm)	mm (to the nearest 10^{th} of a mm)	m
Distance x_2 2^{nd} Band to Central Maximum (mm)	mm (to the nearest 10^{th} of a mm)	m
Distance x_3 3^{rd} Band to Central Maximum (mm)	mm (to the nearest 10^{th} of a mm)	m
Accepted value for wavelength (nm) (printed on laser)	nm	m

ANALYSIS:

1. Using the converted data, calculate the wavelength of light; calculate the wavelength 3 different ways using your 3 values for x (remember that m changes in each calculation).

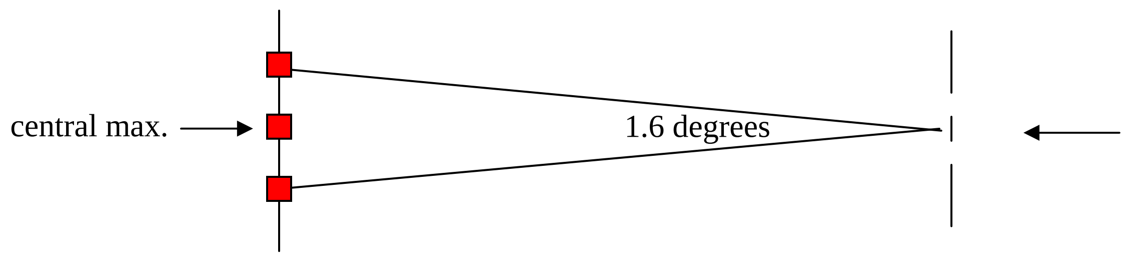
2. Using an <u>average wavelength value</u> from the three calculations above, calculate the error using the known value for the wavelength.

3. Discuss all sources of error.

QUESTIONS:

1. If the color of the laser was blue, would the separation between the central maxima and the first order line be less or more than with red? Defend your answer.

2. A bright monochromatic light passes through two slits separated by 0.05 mm and produces an interference pattern. If an angle of 1.6 degrees is formed from the first order bright band on one side of the central maximum to the first order bright band on the other side of the central maximum, what is the wavelength of the light?



3. Read section 28-2 pgs. 787-789 in your text. If you could shoot just one photon at a time from your laser and record where it strikes the screen with a tiny dot, the photon strikes at first would seem very random on the screen. However, if you allowed the experiment to run for a long time, you would begin to see a pattern emerging (the exact diffraction pattern you observed in lab). How does the observed interference pattern relate to the probability of photons striking the screen at any given position i.e. what is the relative probability of a photon hitting the screen at say m = 0, or at m = 1.5, etc.? Defend your answer.