Online laboratory assignment 12 – Young's double slit experiment

Purpose: to study the interference of light passed through two thin slits.

Introduction

Under certain circumstances, light behaves exactly as if it were a wave. In two-slit interference, light falls on an opaque screen with two closely spaced, narrow slits. As Huygen's principle tells us, each slit acts as a new source. of light. Since the slits are illuminated by the same wave front, these sources are in phase. Where the wave fronts from the two sources overlap, an interference pattern is formed.

The essential geometry of the double-slit experiment is shown in Fig. 1(a). At the zeroth maxima, light rays from slits A and B have traveled the same distance from the slits to your eye, so they are in phase and interfere constructively on your retina. At the first order maxima (to the left of the viewer) light from slit B has traveled one wavelength further than light from slit A, so the rays are again in phase, and constructive interference occurs at this position as well.

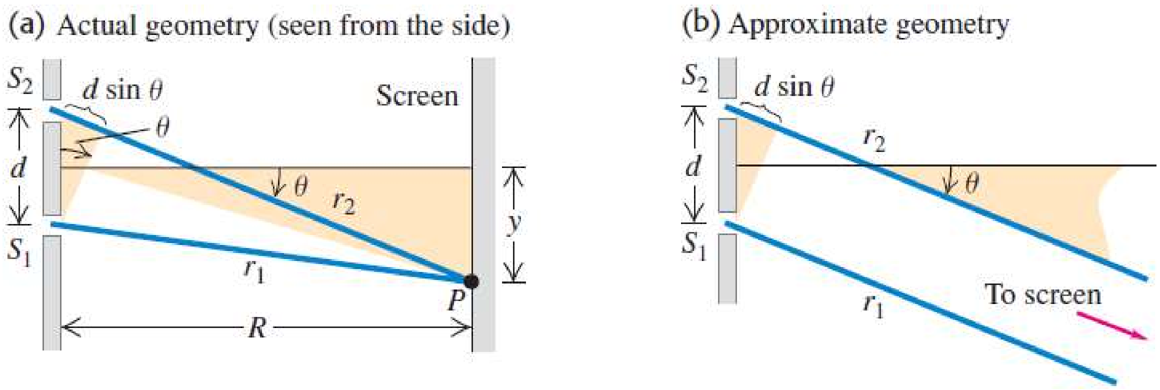


Fig. 1: (a) Double slit experiment and (b) the far-field approximation.

When viewed far away from the slit, the rays are approximately parallel as shown in Fig. 1(b). The resultant equation for the angles at which the constructive interference is at a maximum is

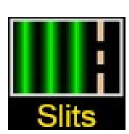
$$d \sin\theta_m = m\lambda \quad \text{where} \quad m = 0, \pm 1, \pm 2, \ldots$$

In class and homework problems, we often encounter the situation in which the angle between adjacent maxima is small, $\theta \ll 1$ radians, and then make the approximation $\theta \approx \sin\theta \approx \tan\theta$. This lab has a relatively short distance between the screen and the slit relative to the slit size, so we must use the sine function. Knowing that $\sin\theta = \frac{y}{\sqrt{R^2+y^2}}$, where y is the distance above or below the center maximum, the maxima in the double slit experiment follow as

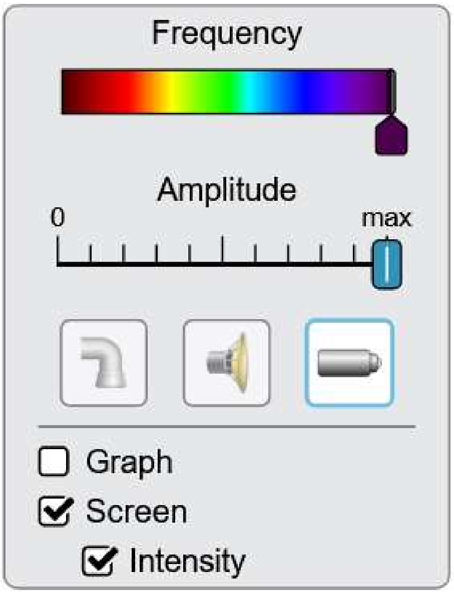
$$y_m \approx \frac{m\lambda R}{\sqrt{d^2 - m^2\lambda^2}} \quad \text{where} \quad m = 0, \pm 1, \pm 2, \ldots$$

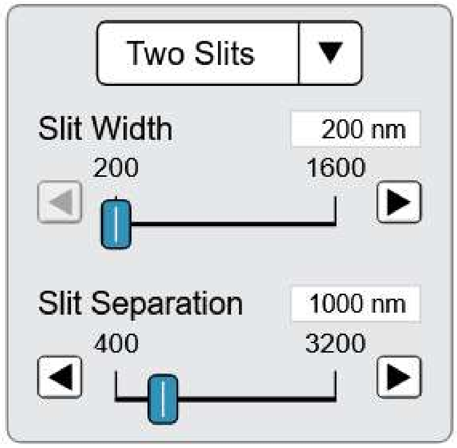
Laboratory assignment

1. Run the "Wave interference" PhET simulation.
2. Select the "Slits" button.

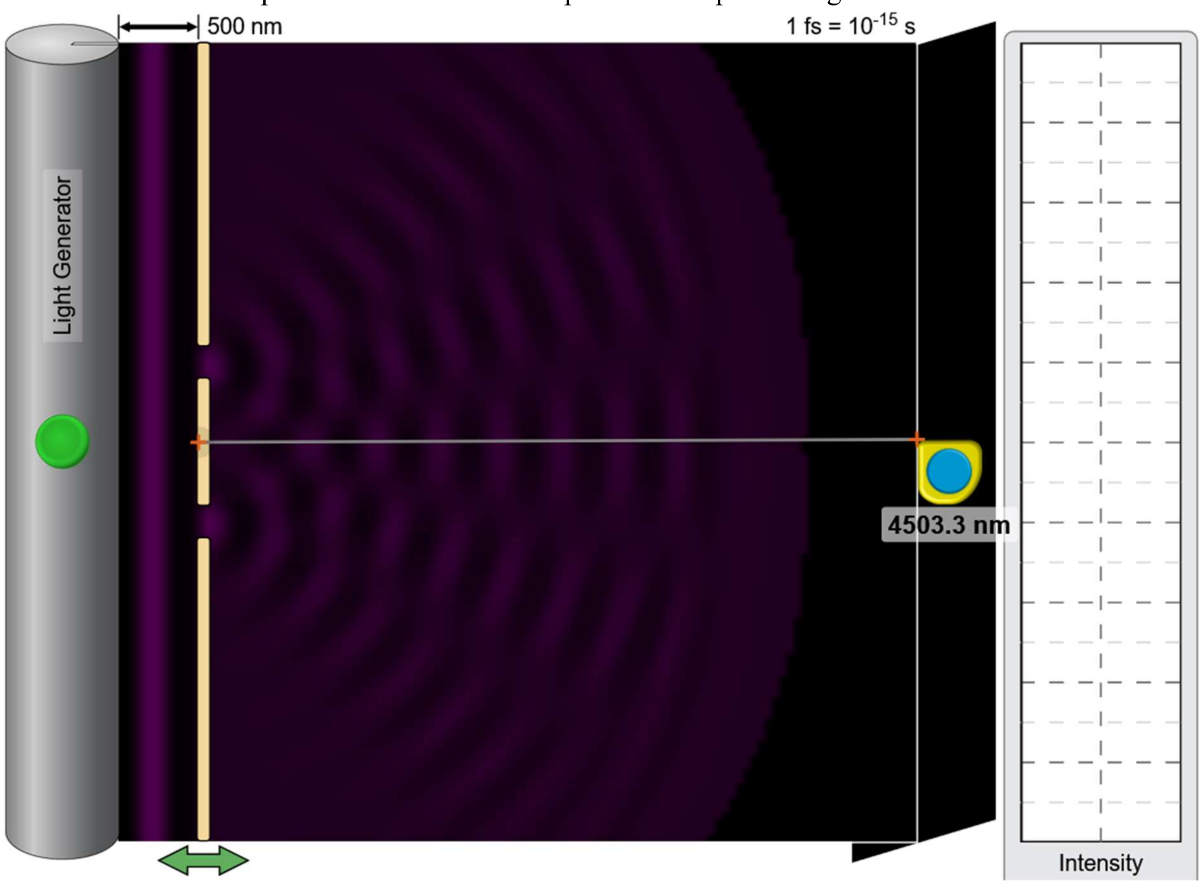


3. First select the laser icon as shown below. Then move the frequency toggle all the way to the farthest right setting, move the amplitude slider to the farthest right setting, check the screen box, and then check the intensity box.

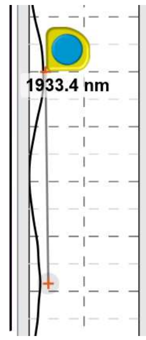




4. Set the single slit width to 200 nm and set the slit width to 1000 nm.
5. Move the slit pattern to the farthest left position and press the green button to turn on the laser.



6. Use the measuring tool to determine that the distance between the double slit pattern and the screen is appropriate, where $R \approx 4500$ nm.
7. Wait until the pattern reaches the screen and a pattern shows up on the intensity graph on the right as shown below. Use the measuring device to determine the distance between the central maximum and the next adjacent maximum. Place the data in Table I.

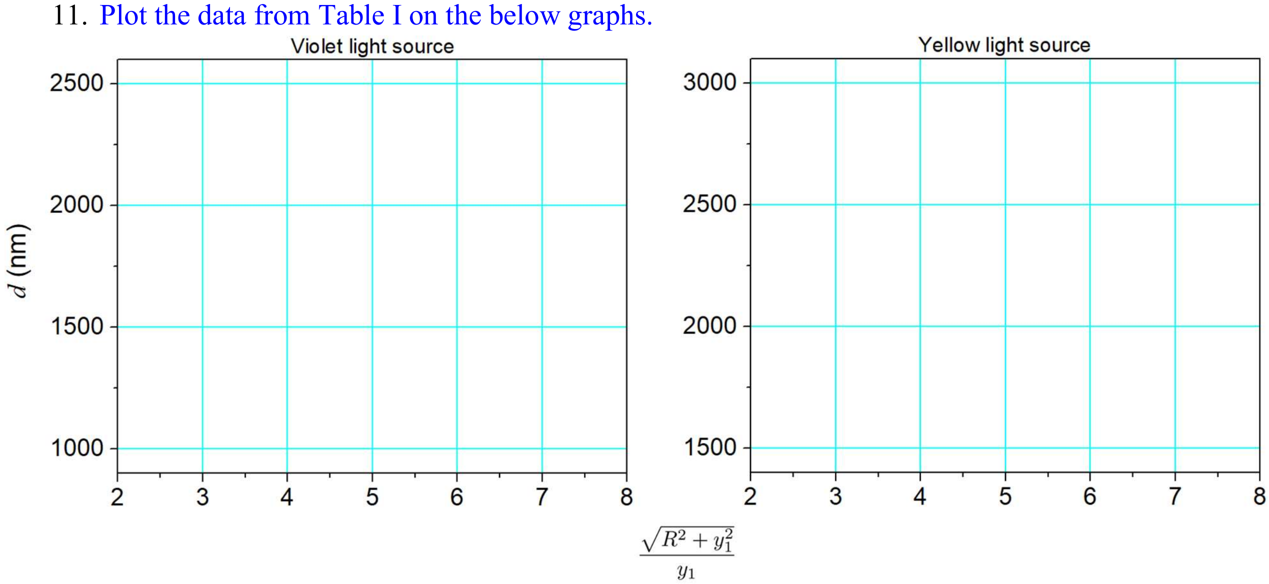


8. Change the slit separation to 1500 nm and repeat the measurement (be sure to wait long enough for the light to pass through the new slit and reach the screen before taking the measurement) and place the data in Table I.
9. Continue the experiment until the "violet light source" region of Table I is complete.
10. Redo the same experiment for a yellow light source after moving the frequency toggle to yellow, but with a range of slit widths between 1500 nm – 3000 nm. Fill in the remainder of Table I.

Table I

Violet light source				
d (nm)	1000	1500	2000	2500
$\lvert y_{\pm 1}\rvert$ (nm)				
Yellow light source				
d (nm)	1500	2000	2500	3000
$\lvert y_{\pm 1}\rvert$ (nm)				

11. Plot the data from Table I on the below graphs.



12. Determine the wavelength and uncertainty (in nanometers) of each light source using the slope of the graph.

λ_{violet} =___________±___________. λ_{yellow} =___________±___________.

13. Write a conclusion to this laboratory assignment.

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