

PocketLab Voyager: Double Slit Diffraction Interference and the Wavelength of Light

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A classic way to demonstrate the wave nature of light is to pass a coherent beam of light from a laser through a double slit. In this lesson, students study the intensity of light in the resultant interference pattern using the light intensity sensor of PocketLab Voyager. In addition, the wavelength of the light can be calculated from knowledge of slit separation, distances between bright fringes in the interference pattern, and distance from the double slit to the pattern. See Figure 1.

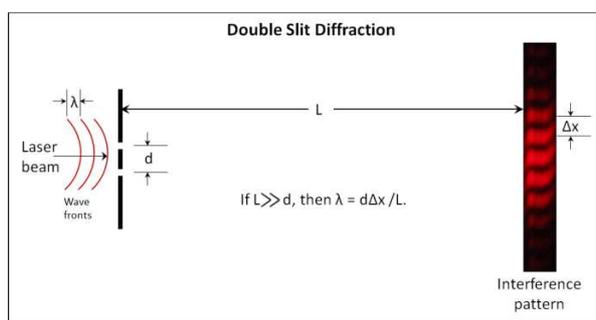


Figure 1

There are ways that you can prepare a double slit, but it is probably best to purchase a slitfilm from an educational science products provider if you want to calculate wavelength, as they are able to supply accurate information on slit size and slit separation d . For our experiment here, $d = 0.03515$ cm, $\Delta x = 1.218$ cm, and $L = 865$ cm, giving a wavelength of 663 nm. The actual wavelength of the red laser pointer used, based upon the manufacturer's specifications, was 650 nm. This results in an error of about 2% in our measurement of the wavelength. See Figure 2 for a picture of the laser and slitfilm setup used.



Figure 2

The real challenge in this experiment is the measurement of the intensity of the nodes in the interference pattern. At a distance d of about 7 meters, the fringes can barely be seen with the naked eye, even in a totally darkened room, using a typical 10 mW red laser pointer. Yet at this distance, the fringes are separated enough to measure Δx with a meter stick.

Solution—borrow a trick used in astronomy. Astronomers are able to capture such beautiful pictures of the heavens because they keep the telescope pointed at exactly the same place in the sky by tracking the region while the earth turns. Their CCD cameras capture light from the sky while tracking. So what we can do is take a long exposure of the fringes with a camera, and then enlarge and study the resulting photo of the fringes while the image is displayed on a computer monitor. A DSLR camera was mounted to a tripod and used to take the picture of the fringes. The ISO reading was set to the highest value possible (6400) to make it most sensitive to light, and the iris to f11. A one-minute exposure was then taken. Adjustments, of course, can be made to adapt these settings to the camera you use. Another picture is also taken with normal room lighting of a meter stick near the location of the fringes. These two photos are combined, as shown in Figure 3. It can be calculated that the average distance Δx between nodes (bright fringes) is about 1.218 cm

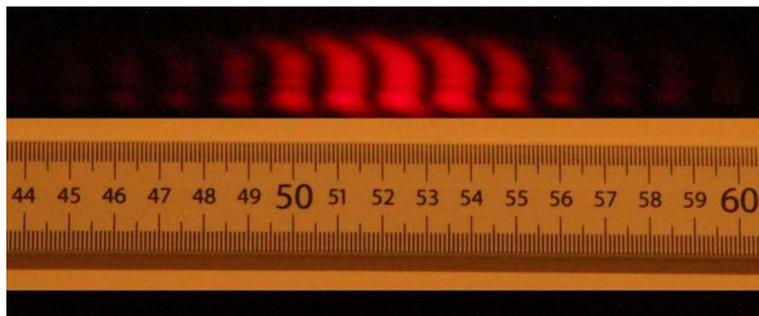


Figure 3

Next comes the fun part involving Voyager and its light intensity sensor!

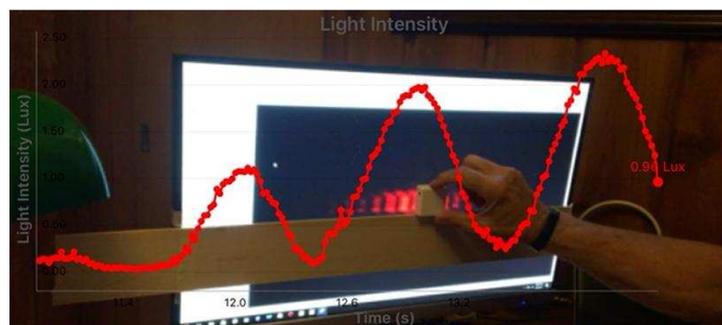


Figure 4

The long exposure photo of the fringes is displayed on the monitor, as shown in Figure 4. A piece of balsa wood (or a meter stick) is taped to the monitor so that when Voyager is placed on the wood stick, the opening for the light intensity sensor is centered on the fringes. The number of points per second

was set to 60. Voyager is then moved from the left to the right on the wood stick over the fringes for a period on the order of ten seconds. Try to move Voyager with as constant a speed as possible. That way the graph of light intensity vs. *time* reasonably approximates the shape of a corresponding graph of light intensity vs. *distance*. A video including a real-time graph of this process, produced with the PocketLab app, accompanies this lesson. See Figure 5, for a snapshot of the graph displayed in the PocketLab app. Note that the light intensity values (in Lux) are about 50 times lower than they should be, as this lesson was prepared before the light intensity sensor was calibrated.

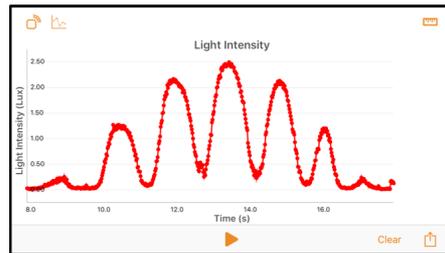


Figure 5

The csv file created by the PocketLab app can be imported and manipulated in Excel as desired. Figure 6 shows such a file as designed by the author. The x-axis time label has been removed since it varies depending on the speed with which Voyager is moved and how constant that speed is kept.

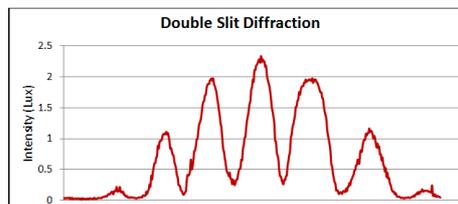


Figure 6

The final step is to compare the intensities from Voyager's light sensor to the theoretical intensities. An Excel program written by the author accompanies this lesson to compute the theoretical intensities for all user defined input parameters. The theoretical intensities for our experiment are shown in Figure 7. The peak intensity values for each of the nodes from Figure 6 agrees extremely well with the theoretical values shown in Figure 7. Success is so much fun!

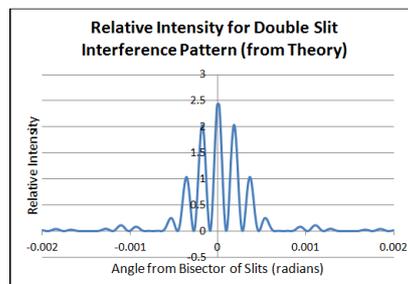


Figure 7

Caution: Never look into a laser beam or its specular reflection.

Additional Investigation

If you have access to a blue or green pen laser, repeat this investigation with that laser.