

TEACHER NOTES

LAB LIGHT 4

RELATED TOPICS Physical Optics
 Light Superposition
 Light Waves

STANDARDS ADDRESSED

Science and Technology

3.1.10, 3.1.12
3.2.10, 3.2.12
3.4.10, 3.4.12

CONSIDERATIONS

1. The availability of small modestly priced battery operated lasers has been very helpful for experiments such as this requiring a well-collimated monochromatic light source. While these lasers are of low energy output, however, the high concentration of the beam is such that care is to be taken that the laser beam, including reflections, does not directly shine in anyone's eyes.
2. The arrangement should be set up that the beam projects approximately "horizontally." The laser tilt can be adjusted with a shim or shims placed under the mount.
3. If space allows a "longer" such as 2 meters or more projection distance between the slit- or slits-to-the-screen is helpful in obtaining larger dimension diffraction/interference patterns.

SAMPLE RESULTS

Particularly for single slit, choosing the minimum positions for making measurements involves significant uncertainty. The precision of the given wavelength value of 650 nm for these lasers is not known.

For the double slit, the position values in Table 2.1 were checked with respect to counting 27 fringes under the central diffraction envelope spanning 3.9 cm thus obtaining quite good measurements for these narrow fringes.

Table 1.1: Data and Results for the 0.04 mm Single Slit

Slit-to-screen distance (D)= 1.00m

	First Order (m=1)	Second Order (m=2)
Distance between side orders	3.50 cm	6.90 cm
Distance from center to side (y)	1.75 cm	3.45 cm
Calculated slit width	0.037 mm	0.038 mm
% difference	7.5	5

Table 2.1: Data and Results for the 0.04mm/0.25 mm Double Slit

Slit-to-distance (D)= 1.00 m

	First Order (m=1)	Second Order (m=2)
Distance between side orders	5.10 mm	10.20 mm
Distance from center to side (y)	2.55 mm	5.10 mm
Calculated slit separation	0.255 mm	0.255 mm
% difference	2	2

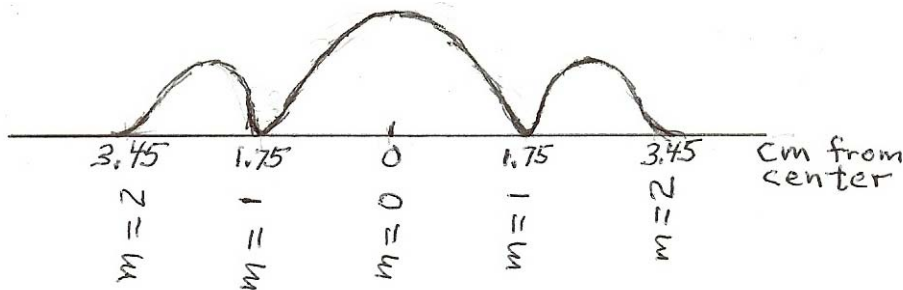
ANSWERS TO PRELIMINARY QUESTIONS

1. We model a beam of light to be composed of sinusoidal waves vibrating transverse to the direction of propagation. With a narrow well-collimated monochromatic (single wavelength) beam and bending due to diffraction, the light wavelets from various points of the wave-front when passing through a slit are traveling different distances laterally from the slit to the screen so superimpose with varying phase differences so as to yield patterns ranging from bright areas where the waves superimpose in phase (travel distance differences of integral number of wavelengths) to dark areas where the waves superimpose out of phase (travel distance differences of an odd number of one-half wavelengths).

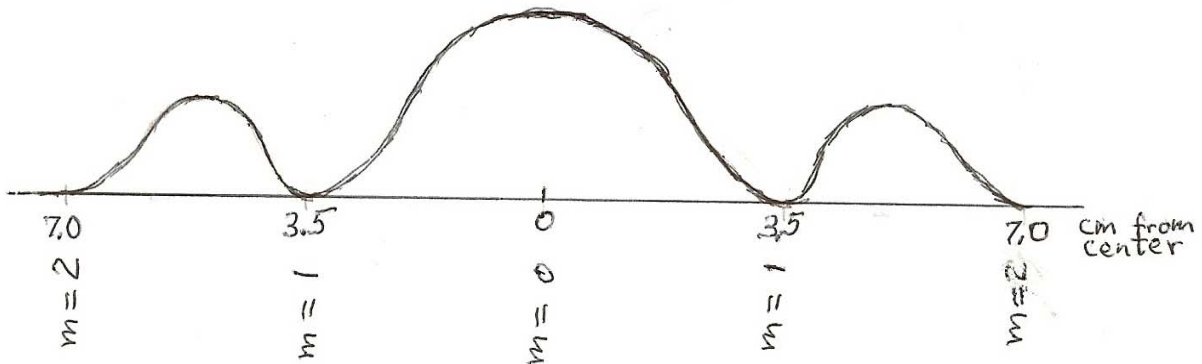
2. Closely related to the previous questions, with the wavelets superimposing, the geometry involving the wavelength of the light and in relation to slit width and separation (if double-slit) and the distance from the slit(s)-to-screen determines the positions of varying intensity on the screen such that for narrower slit the diffraction/interference pattern is more spread out requiring a greater distance from the “center-line” to result in particular wavelength travel difference.
3. Generally, ordinary light beams involve combination of many different wavelengths hence various diffraction/interference intensity patterns superimposed, are likely not well-collimated so that the wavelets would not directionally match well as they superimpose, and would involve a beam width so as to “wash-out” wavelet pattern affects.

ANSWERS TO PROCEDURE QUESTIONS

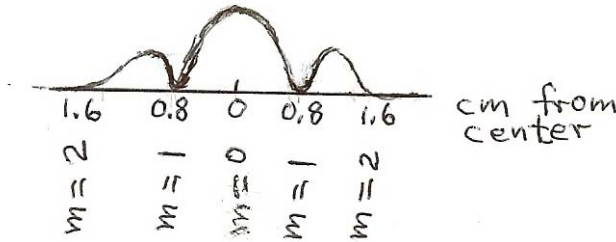
5. Sketch of 0.04 mm single slit diffraction/interference pattern



6. Sketch of 0.02 mm single slit diffraction/interference pattern

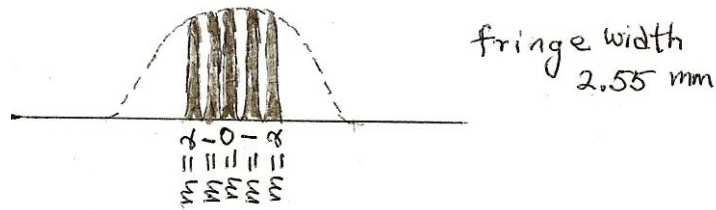


Sketch of 0.08 mm single slit diffraction/interference pattern

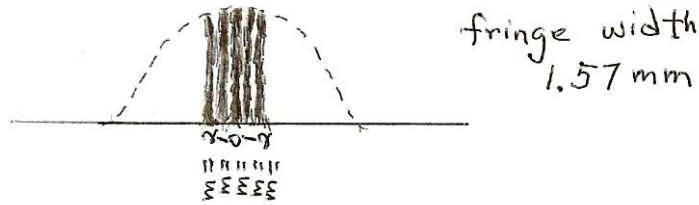


Note that for these observation based sketches for single slit and the following for double slit, the slit(s)-to-screen distances were 1.00 meter. Especially for the double slit rather “fine” fringes, larger slits-to-screen distance would expand the pattern.

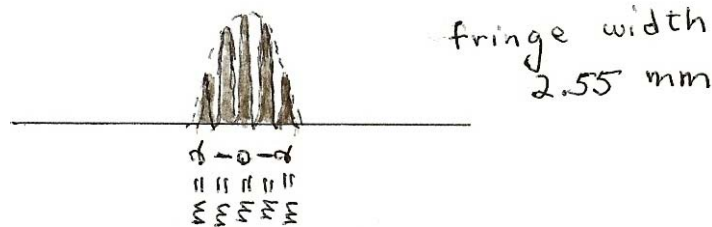
9. Sketch of double slit, slit width 0.04mm and slit separation of 0.25 mm



10. Sketch of double slit, slit width of 0.04 mm and slit separation of 0.50 mm

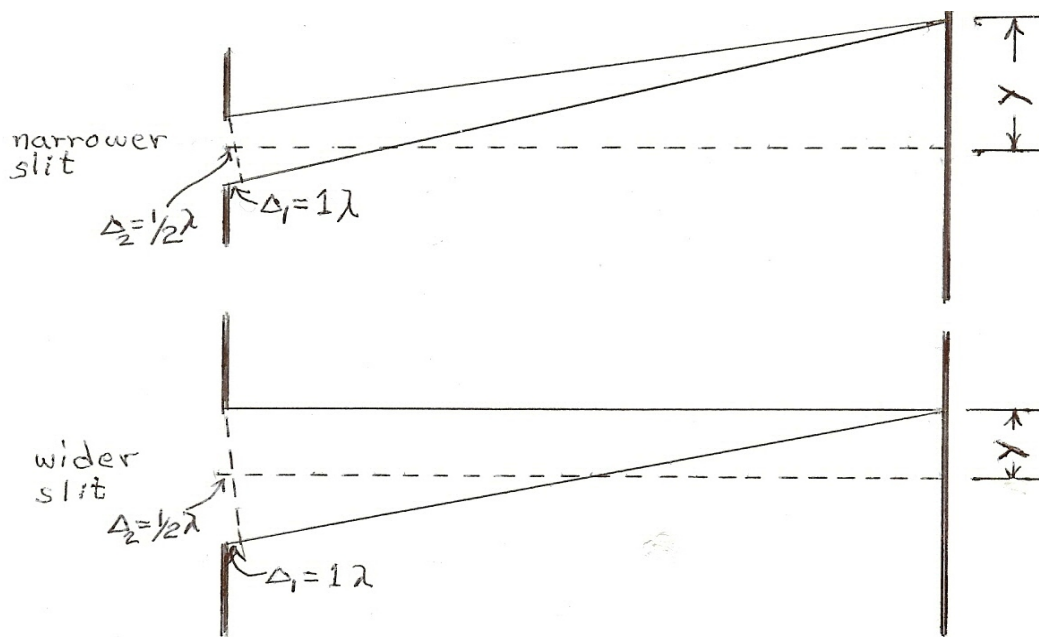


11. Sketch of double slit, slit width 0.08 mm and slit separation of 0.25mm



ANSWERS TO QUESTIONS

1. The distance between minima decreases as slit width increases. Note answers to “preliminary questions” 1 and 2 that based on the geometry of the arrangement, such as diffraction pattern points of “greater” intensity differing by an integral number of wavelengths are less spread out or deviated from the center line for wider slits. Note the sketches below where y corresponding to a minimum is greater for the narrower slit.



The point on the screen where the two lines shown converge is a minimum when Δ_1 as indicated is 1λ , that is Δ_2 at midpoint of slit is $1/2\lambda$ so that moving across the slit wavefront taking pairs of points differing by $1/2\lambda$ so of opposite phase, the full beam cancels.

2. Similar to single slit behavior as slit separation is increased the maxima become closer together.
3. The distance between the maxima of double slit interference remains the same with respect to changes in slit width.
4. The distance between the minima of the diffraction envelope due to single slit affects remains the same with respect to changes in slit separation.

5. Decreases
6. The more detailed “finer” fringes result from double slit light interference while the superimposed coarser overall varying light intensity results from single slit light interference. This would follow from the geometry with slit separation being greater than slit width.