PY 106 (Summer II)

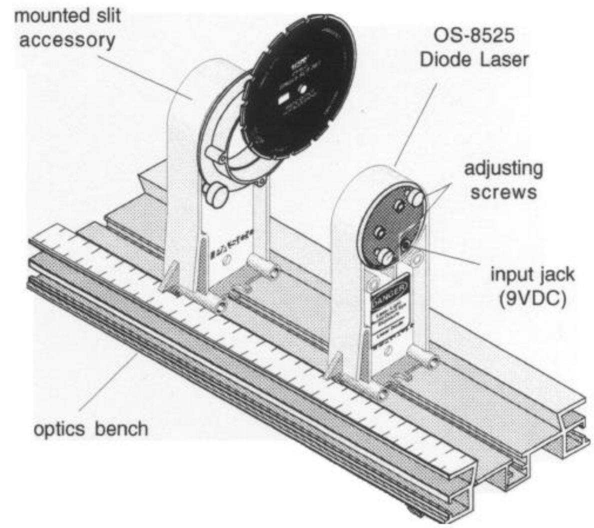
Section: Name: BU ID: .

Partner: Name: BU ID: .

Lab 8: Diffraction and Interference

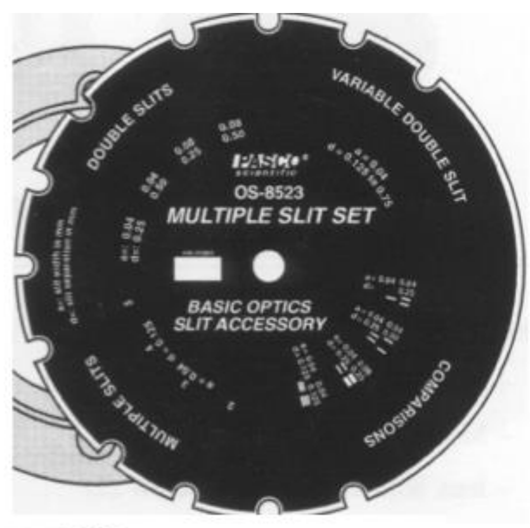
Part I: Interference.

In this experiment, you will demonstrate the wave nature of light by investigating how light bends around edges and interferes constructively and destructively. You will observe these effects in a variety of situations and use the wave theory of light to measure wavelength.



APPARATUS

- o Optical rail with cm marks
- o Screen and paper at the end of the optical rail
- o Multiple Slit patterns wheel and diffraction grating
- o Laser diode source with vertical and horizontal positioning
- o LoggerPro (or PASCO) interface to measure locations of maxima and/or minima (file DiffractInterf.cmbl in Summer II folder)



Position the laser at one end of the optical rail. Place the Multiple slit set 5 – 10 cm in front of the laser with the text facing the laser. Squeezing the base of the holders and sliding them along or angling them allows for motion and changing of the slit disks and laser. Rotate the slit to one of the double slits so the double slit is in position to be hit by the laser.

Optimize the position of the laser by slowly rotating the horizontal and vertical adjustment screws on the back of the laser. When you have the laser aligned so the beam hits the double slit, optimize the alignment by looking at the pattern formed on the screen. Find the alignment with the brightest, most centrally located pattern (to take clear measurements, try different apertures from the aperture wheel attached to a light sensor, try different gain settings of the light sensor).

To go to a new slit or pattern simply rotate the double slit ring and a different slit should click into the correct position. You may need to make small adjustments for the different slits and patterns.

Select the double slit with 0.04 mm slit width and 0.25 mm slit separation by rotating the multiple slit disk until the needed slit is centered in the holder. Adjust the position of the beam and optimize the pattern on the screen.

1. Draw a picture of the pattern on the screen. Find a way to depict the intensity of the light.

2. Draw a schematic for the experiment and clearly indicate the light source, the screen, the minima of the pattern, and all the important distances and angles. Label the central maximum, the 1st maximum, and the 1st minimum.

3. Write an exact expression which relates the slit separation d with the wavelength of light λ and the angle between the direction toward the *m*-th *maximum* and the horizontal θ_m.

4. Using your exact expression from question 3, write an approximate expression based on the fact that the angles θ_m are small (when measured in radians).

5. Write an exact expression which relates the slit separation d with the wavelength of light λ and the angle between the direction toward the *m*-th *minimum* and the horizontal θ_m.

6. Using your expression from question 5, write an approximate expression based on the fact that the angles θ_m are small.

You can choose whether to use minima or maxima in your experiment to measure the wavelength of the laser beam. Write down your choice.

____

7. Write an exact expression which relates, L, the distance from the source to the screen, y_m, the distance from the central maximum to the minimum/maximum (your choice!) of the m-th order, and, θ_m the angle between the direction toward the m-th minimum/maximum and the horizontal.

8. Based on the fact that the angles θ_m are small, write an approximate expression for equation in part 7.

9. Combine your expressions from above and write an (approximate) expression which relates, L, the distance from the source to the screen, y_m, the distance from the central maximum to the minimum/maximum (of your choice!) of the m-th order, d, the slit separation, and λ, the wavelength.

10. You will use the previous expression to measure the wavelength of the laser beam. Solve that expression for the wavelength λ.

λ =

11. Measure and write down below all the variables needed to conduct the final calculation. Clearly indicate the order of the maximum/minimum which you are using.

12. Calculate the wavelength of the laser beam.

$\lambda =$

13. If you were using maxima, switch to minima; if you were using minima, switch to maxima, repeat the measurements and calculations and find the wavelength again.

$\lambda =$

14. Use the variable double-slit to check how the pattern changes with increasing and decreasing separation of the slits. Describe your observations.

15. Draw a pattern for a wider slit separation: $d =$ ___________

16. Describe the changes happening to the pattern when you move the slits closer/farther relative to the screen.

17. Draw a pattern for a double-slit when it is closer to the screen.

Part I(a)

18.

Take one diffraction grating (but, please, do not take it with you after the lab!). Place a sheet of a white paper on a tabletop and use it as a screen to investigate the pattern created by a diffraction grating. Keep a laser at about 15 cm above the tabletop, point it directly down, place a diffraction grating between the laser and the "screen" and ***only then*** turn the laser on (one students should hold the laser, and another one should hold the grating).

DO NOT LOOK INTO THE LASER !!

Draw a picture of the interference pattern you see in your experiment.

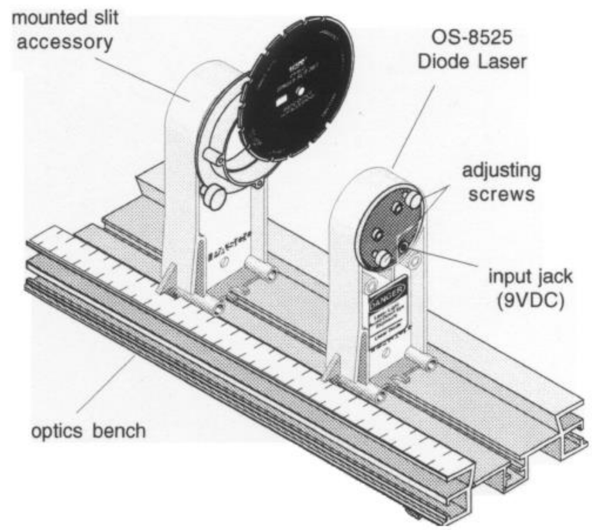
19. What is happening to the pattern when you are changing the distance between the screen and the grating (move the grating up and down)? What is happening to the pattern when you are changing the distance between the laser and the grating (move the laser up and down)?

20. Which condition can you use to describe mathematically the pattern in part 18 and the changes in part 19?

[ ] only the condition for maxima

[ ] only the condition for minima

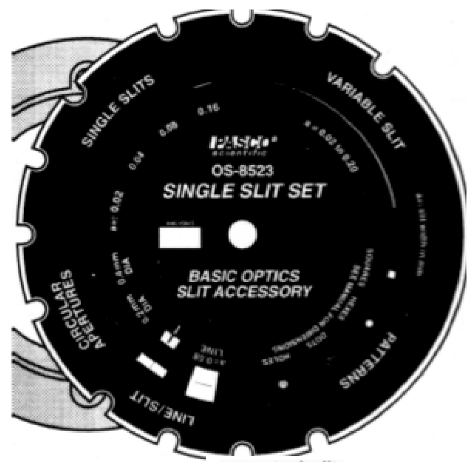
[ ] both



Part II: Diffraction.

In this experiment you will demonstrate the wave nature of light by investigating how light bends around edges and interferes constructively and destructively. You will observe these effects in a variety of situations and use the wave theory of light to measure its wavelength.

APPARATUS



o Optical rail with cm marks

o Screen and paper at the end of the optical rail

o Single Slit patterns wheel

o Laser diode source with vertical and horizontal positioning

o LoggerPro (or PASCO) interface to measure locations of maxima and/or minima (file DiffractInterf.cmbl in Summer II folder)

Position the laser at one end of the optical rail. Place the Single slit set 5 – 10 cm in front of the laser with the text facing the laser. Squeezing the base of the holders and sliding them along or angling them allows for motion and changing of the slit disks and laser. Rotate the slit to one of the single slits so the single slit is in position to be hit by the laser.

Optimize the position of the laser by slowly rotating the horizontal and vertical adjustment screws on the back of the laser. When you have the laser aligned so the beam hits the single slit, optimize the alignment by looking *at the pattern* formed on the screen **(do not look directly into the laser!!)**. Find the alignment with the brightest, most centrally located pattern.

To go to a new slit or pattern simply rotate the single slit ring and a different slit should click into the correct position. You may need to make small adjustments for the different slits and patterns.

Select the single 0.04 mm slit by rotating the single slit disk until the 0.04 mm slit is centered in the holder.

Adjust the position of the beam and optimize the pattern on the screen.

1. Draw a picture of the pattern on the screen. Find a way to depict the intensity of the light.

2. Draw a schematic for the experiment and clearly indicate the light source, the screen, the minima of the pattern, and all the important distances and angles.

3. Write an exact expression which relates the width of the slit a with the wavelength of light λ□and the angle between the direction toward the m-th minimum and the horizontal θ_m.

4. Using your expression from question 3, write an approximate expression based on the fact that the angles θ_m are small (and measured in radians).

5. Write an exact expression which relates the distance from the source to the screen, L, the distance from the central maximum to the minimum of the m-th order, y_m, and the angle between the direction toward the m-th minimum and the horizontal, θ_m.

6. Based on the fact that the angles θ_m are small, write an approximate expression which relates the distance from the source to the screen L, the distance from the central maximum to the minimum of the m-th order y_m, and the angle between the direction toward the m-th minimum and the horizontal θ_m.

7. Combine your expressions from (4) and (6) and write an (approximate) expression which relates the distance from the source to the screen, L, the distance from the central maximum to the minimum of the m-th order, y_m, the slit width w, and the wavelength, λ.

8. You will use the expression in part 7 to measure the wavelength of the laser beam. Solve that expression for the wavelength λ.

$\lambda =$

9. Run the experiment. Measure and write down all the variables needed to conduct the final calculation. Clearly indicate the order of the minimum which you are using.

10. Calculate the wavelength of the laser beam.

$\lambda =$

11. Rotate the slit apparatus to the 0.02 mm slit and the 0.08 mm slit, and try the variable slit. Describe the changes happening to the pattern as the slit width decreases/increases.

12. Draw a pattern for a slit of width $w = 0.08$ mm.

13. Set the slit to width $w = 0.08$ mm and repeat the measurements and calculations, to find λ again.

$\lambda =$

14. Describe the changes happening to the pattern while you move the slit closer/farther relative to the screen.

15. Draw a pattern for the slit which is closer to the screen.

Equipment

Lab 8 (12 tables): Diffraction and Interference Apparatus (single slit, double slit; a grating), a sheep of paper.

Unit layout

L8: 160 min

PI: 80 min

PII: 80 min

PE9: 40 min

Breaks when needed.

Practice Exercise 8

Part I

Take two small polarizers (but, please, do not take them with you after the lab!). Look through one polarizer while turning it up to 90 degrees.
Does the intensity of light passing through the polarizer depend on the angle in this experiment? Comment.

Now, take the second polarizer and place it across the first one. Slowly rotate the second polarizer relative to the first one. Does the intensity of light passing through the polarizer depend on the angle in this experiment? Comment.

Part II

An air wedge is formed by two 10 cm long glass slides which are being illuminated by pure 500 nm wavelength light incident perpendicularly. The top slide touches the bottom slide at one end and another end of the top slide rests on a hair which is 20 μm thick. How far apart from each other the dark bands of the pattern?
Note: there should be at least a couple of similar glass wedges in the room, as well as a Newton ring setup, and an anti-reflective filter; you should try to see colored lines produced by a thin film interference in the air wedge and test other devices.