

Laboratory #5Week of February 13

- Read: pp. 449-475 and pp. 488-494 of "Optics" by Hecht
- Do:
1. Experiment V.1: Single slit diffraction and double slit interference
 2. Experiment V.2: Multi-slit diffraction and diffraction grating
 3. Experiment V.3: Fun: distance between grooves on a CD

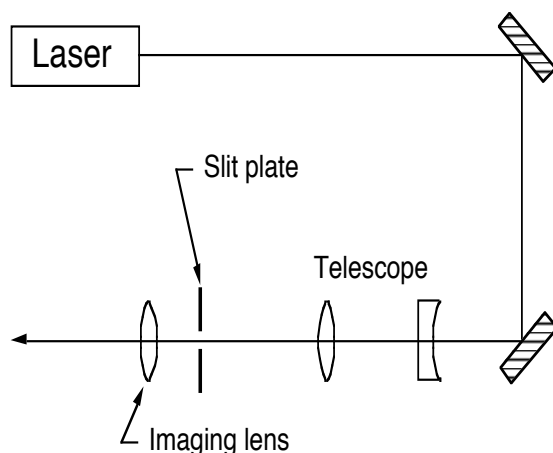
Experiment V.1: Single slit diffraction and double slit interference

In this experiment you will explore the phenomena of diffraction and interference from single and double slits. You will use your data to determine the slit width b and the slit spacing a . The schematic for this experiment is shown below. All the components in the third arm are mounted on an optical rail for ease of alignment. The telescope produces a large beam, which is needed for some of the slit patterns. Once aligned, you can easily remove the lenses to use the original laser beam. The Cornell slit plates can be held in a filter holder. The diffraction and interference patterns can be viewed on a white board placed at the end of the table or on the wall (nothing off the wall please). You may want to consider magnifying the diffraction pattern using a lens to increase your measurement accuracy. Tools such as a 25 mm imaging lens will allow you to directly image the slits so you can see what they look like and verify the dimensions. You can also use the USB camera to take pictures and measurements of your diffraction patterns – just make sure to decrease the beam intensity beforehand so you do not saturate the camera.

The Cornell slit plate has five columns, each with five slit patterns. One column contains 1 slit, 2 slits, 3 slits, 4 slits, and 10 slits with equal widths. Use the single slit to form a diffraction pattern. Measure the positions of the dark fringes and use the equation for the diffraction pattern:

$$b \sin \theta_m = m\lambda ,$$

to find the slit width b . Use the double slit from the same column to form an interference pattern. Measure the positions of the bright fringes and use the equation for Young's double slits:



$$a \sin \theta_m = m\lambda ,$$

to find the slit spacing a . From these two measurements, you can find the ratio a/b . How could you find this ratio in a simpler manner from the double slit pattern? Consider using the small angle approximation to simplify the above equations. Now use the short focal length lens to image the slit patterns,

directly measure the slit spacing and width (by measuring them on the image and accounting for lens magnification), and verify your results obtained from the diffraction pattern analysis.

Experiment V.2: Multi-slit diffraction and diffraction grating

Observe the patterns formed by 3, 4 and 10 slits. Notice how the interference maxima become narrower as the number of slits increases. Compare your patterns with Eq. 10.35 (p. 475) and Fig. 10.22 of Hecht. Be sure you understand whether you are observing the principal or subsidiary maxima! Measure the ratio a/b . Is it the same for all five slit patterns in this column? How can you determine the number of slits from looking at the diffraction pattern?

Observe the diffraction pattern from the diffraction grating (in a slide mount) (See Fig. 10.42 of Hecht). Measure the positions of the diffraction peaks and determine the grating spacing a . What happens if you change the angle of incidence on the diffraction grating? Verify your theoretical prediction.

Replace the laser with the incandescent lamp as a white light source, collimate the beam as well as possible, and direct it onto the grating at normal incidence. Measure the approximate angular difference between the most violet (nearest UV) and most red (nearest IR) portions of the spectrum that you can see. From the grating equation, what are the wavelengths of these two colors?

Experiment V.3: Fun

A CD (Compact Disc) is a fun example of a diffraction grating. Using the HeNe laser, determine the distance between the grooves.

Equipment needed:

Item	Qty	Source (part #)
Helium-Neon Laser	1	Melles Griot 05 LHP 121
Lamp (incandescent)	1	
USB Camera	1	
Cornell slit plate	1	
Diffraction grating slide	1	
CD	1	
Optical Rail	1	Newport PRL-36
Rail carriage	5	Newport PRC-1
Mirror mount	2	Thor Labs KM1
Al mirror	2	Newport 10D10ER.1
100 mm lens	1	Newport KPX094
25 mm lens	1	Newport KPX076
-25 mm lens	1	Newport KPX043
Iris (adjustable)	1	Thor Labs ID12
Target holder	2	Thor Labs FH2
Target	1	
Mounting posts	7	Thor Labs P3
Cards (for laser blocking)	limitless	
Laser block	1	
Ruler	1	