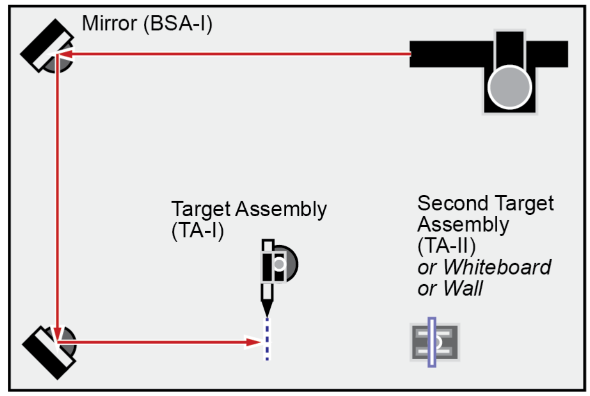
# Week #4 – Diffraction

Reminder, still practice good optics alignment and Laser Safety practices! You may need to darken the room and use cell-phones or lamps as light sources… You can use photos instead of diagrams/or drawings in your lab report where ever it is appropriate and where they can be properly labeled/understood.

***1. Single Slit Diffraction, Double Slit Interference*** **-** Goal: (a) determine slit width for single slit; (b) determine slit spacing for double slit.




*Make sure you have the right slit width, look at the slit with a light behind it and make sure it is the right one! The laser beam is larger than the vertical height of the slit, so you will get some vertical diffraction pattern (which should be ignored).*

Procedure:

(1) For the single slit measurement place the single slit (TSS, 0.002”) in the target assembly (TA-1) center the laser beam onto the slit. Mount TA-1 about 5” away from the 2$^{nd}$ mirror.

(2) Adjust the 2$^{nd}$ BSA if needed to fully illuminate the slit. This is best achieved by viewing the backside of the slit at ~45 degrees and looking for a bright red glow. You should also obtain the brightest/clearest diffraction pattern that you can on the white index card located in TA-**II**.

(3) Mark on the index cards as many dark bands as possible. An easy way to measure the distance from the center band to the dark bands is to measure the distance between equal dark bands and simply divide by 2. Calculate the single slit width using the equations provided in lecture.

(4) Next, test the double slit (TDS, 0.002” wide slits that are 0.008” apart, 0.001” = 25.4 μm). Then use equations found in the lecture to experimentally calculate the slit separation.

(5) Lastly, try to use something to block laser light to one of the two slits, and confirm that you get back to the single slit case again…

***2. Pencil Lead*** **–** Goal: show you can use diffraction to measure the width of really narrow objects.

Procedure:

(1) Use the same setup, but using the second BSA direct the beam to the opposing wall.

(2) Place a mechanical pencil lead right after the 2nd mirror and determine the diameter of the lead. (You must use provided lead, inside blue utility boxes or the bins, put the lead back in the container when you are done.)

(3) Use what you learned in lecture to calculate the width of the pencil lead. *Hint, straight edges also cause diffraction, and like a double slit act as two point sources of light.*

***3. Grating Measurement -*** Goal: determine spacing of a grating.

Procedure:

(1) Use the same setup, but place the 1000 lines/mm grating in the laser beam and comment on what you see (no need to calculate, you should see three dots with the outer two representing the first diffractive mode, m=1).

(2) Calculate the expected diffraction angle for 1000 lines/mm and m=1 using the equations provided in lecture. Does this roughly match what you observe? Second question, why don’t we see the m=2 diffractive mode?

***4. D.O.C Test Cards -*** Goal: have some fun with really cool diffraction cards and understand a key limit of diffraction.

Procedure:

(1) Obtain a D.O.C. test card from the cabinet, is a plastic film in a green or blue envelope, and the test features are all listed on one side of the envelope.

(2) Use a wall to image all the diffraction patterns.

(3) Use the flat diffractive lens on the test card to focus the beam to the smallest possible point. This should be at the focal point of the lens. Record the focal length.

(4) Use this same lens to magnify black text on white paper. You will notice coloration/fringes around the text. Why do we see this? This is important as it tells you a limitation of diffractive optics!

***5. Setup Dismantle and Storage*** **–** Proper care of optical components is just as important to achieving reliable results as is careful experimental setup. Improper handling, setup, dismantling, and storage will detract from your final grade in this course. Unsure about any component? Just ask. The next group should find all parts neatly stored in the optics kit. There is a card with each kit that shows where each component goes.

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***6. Theoretical/Calculation Problem*** **-** Revise the MATLAB code below to theoretically plot the Single Slit diffraction intensity for experiment #1 (enter in the correct slit width, etc..). Include this plot with that portion of your lab report.

On blackboard, there is a MATLAB simulator (courtesy of a previous group) which can use for comparison to your results using the code below, but you must use the more raw code below to generate your own plots for the lab report.

```
% File: http://web.mit.edu/8.13/matlab/Examples/singleslit.m
% Date: 2008-June-13
% Author: Scott Sewell

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% From Eugene Hecht's Optics: 4th Edition, Equation 10.17
% singleslit(b,l,f) plots the single slit diffraction pattern for
% a slit of width 'b' in mm
% a wavelength of 'l' in nm
% a slit-to-screen distance of 'f' in m.
% Produces a plot of intensity versus screen position in mm.
% I(theta) = I(0)sinc^2(Beta) where Beta = pi b/l
% One can see that 'Beta' is a relative measure of the width of the
% diffracting slit and the wavelength of light
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
b1=.1;
b2=.05;
l=632;
f=0.5;

theta=[-.02:.0001:.02];
beta1=pi*(b1/1000)/(l/1e9).*sin(theta);
beta2=pi*(b2/1000)/(l/1e9).*sin(theta);
y1=(sin(beta1)./beta1).^2;
y2=(sin(beta2)./beta2).^2;
plot(theta*f*1000,y1);
hold on;
plot(theta*f*1000,y2,'--');
legend('100\mum slit','50 \mum slit');
title('Diffraction pattern from a HeNe laser through a single slit at 50cm distance');
xlabel('Position on Screen [mm]')
ylabel('Intensity');
```