Diffraction and Interference
Spring 2014

Introduction

This lab consists of three self-contained experiments. Each experiment demonstrates some aspect of the principle of diffraction and interference.

I. *The diffraction pattern of one and two slits*:

In this experiment you will see the diffraction and interference patterns resulting from single-slit and double-slit apertures, and then observe the effect of increasing the slit width and the spacing between slits. ***Note**: lasers are used in this experiment; exercise caution at all times!*

a. One optical bench projects a laser beam through a single narrow slit. Sketch the pattern that appears on the screen.

b. Slowly rotate the disc counterclockwise, and observe the change in the pattern as the slit width increases (stop turning the wheel when the pattern disappears). Sketch the pattern with the slit width at its widest setting. Describe how the pattern changed as the width increased.

c. The other optical bench projects a laser beam through a pair of closely spaced slits; each slit is the same width as the single slit on the first optical bench. Sketch the pattern observed, and discuss the effect on the pattern compared to that viewed in part (a).

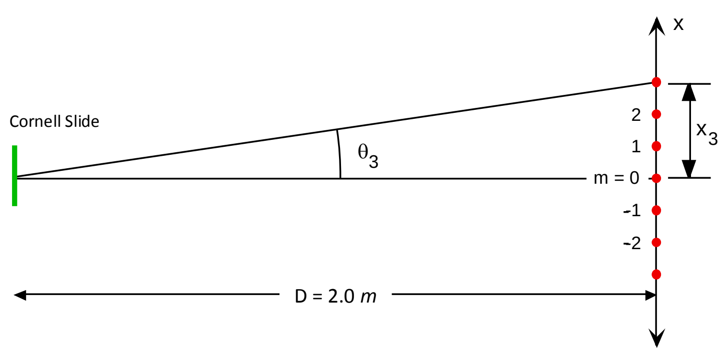
d. Slowly rotate the disc counterclockwise; this will increase the separation of the slits (the width of each slit remains constant). Look closely at the pattern observed when the separation is at its widest, sketch it and again describe how the pattern changed.

e. Reset both discs to their initial positions when finished.

II. *The wavelength of the red light of hydrogen:*

The diffraction pattern of very many extremely narrow slits (instead of one or two as above) is a set of images of the incoming light source, bent at angles depending on the wavelength: $m\lambda = d \sin\theta$, where **d** is the spacing between the slits, θ is the angle bent, **m** = 0, ±1, ±2 . . . is the *order* of the image observed, and λ is the wavelength of light. The value of **d** for the diffraction grating in the middle of the glass Cornell slide is 32,700 *nm* (that's 32,700 *billionths* of a meter!).

a. Pick up the Cornell Slide and look at the incandescent bulb at the back of the lab through the central diffraction grating. You will see the bulb itself (this is the 0^{th} order image), and multiple copies of the colorful pattern shown in Part III. Each copy of this pattern represents an image order.



b. Place the Cornell Slide diffraction grating at the end of the meter stick which has been fixed to the lab bench; this will place the grating **D** = 2.0 *m* in front of the hydrogen tube. While looking at the hydrogen tube through the grating, have your partner move the little lamps on the meter stick in front of the tube to line up with the *red* diffracted hydrogen m = ±1, ±2 and ±3 images (to the left and right of the hydrogen tube). Label the positions of the lamps x_{+1}, x_{-1}, etc.

c. Since the hydrogen tube may not be centered on the meter stick, calculate the difference between the two measurements for a pair of images and divide by 2 to determine the length of *x*. Do this for all three pairs of images.

d. The angle θ is sufficiently small so that the *small angle approximation* can be applied:

$$\sin\theta \approx \tan\theta = \frac{x}{D}$$

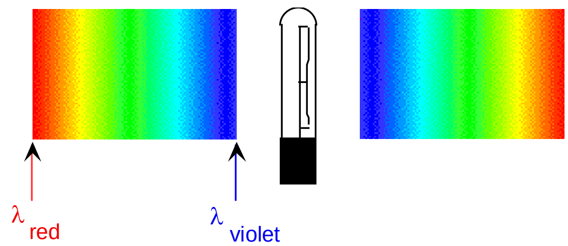
So, our equation becomes:

$$m\lambda = d\left(\frac{x_m}{D}\right)$$

Calculate λ for each order image, then calculate the average of the three values. Compare your average with the accepted wavelength: $\lambda_{red} = 656.3\ nm$.

III. *The color limits of your vision:*

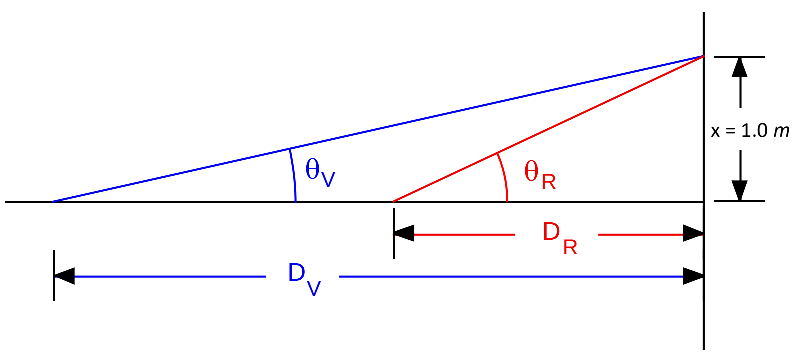
At the back of the lab there is an incandescent bulb mounted on the wall. Look at the bulb through one of the 2×2 slide gratings (d = 1900 *nm* for these gratings). You'll see a pattern similar to that shown at right (if the colors appear above and below the bulb, rotate the grating by 90°). You will be measuring the range of wavelengths that you can see by examining this *continuous spectrum* on the left side of the bulb.



a. Turn around and look at the hydrogen tube through the 2×2 grating. Note that you only see the 0^{th} and 1^{st} order image of the spectral lines. Now look through the grating at the incandescent bulb. You should note the difference in appearance of both diffraction patterns when looking through the 2×2 grating as compared to the Cornell Slide in Part II.

b. A meter stick is placed behind the bulb, with a pointer indicating a distance x = 1.0 *m* from the filament in the bulb. While looking at the bulb through the grating, move closer to or farther away from the bulb until the *outermost edge* of the red area is located at this pointer. Using a 2-*m* stick as a "staff", measure your distance **D** from the bulb. Repeat your distance measurement for the *innermost edge* of the blue region. Have each person in your group take these measurements so that you can compare your results.

c. Use trigonometry to calculate θ at each position, then calculate the wavelengths of the most extreme red and blue that you can see (what is the value of **m**?). Note that the angles are sufficiently large so that you *can't* use the small angle approximation for this experiment!



d. Compare your measured wavelengths to the theoretical color range of vision: 400 *nm* (violet) – 700 *nm* (red). Record your partner's measured values of λ, and comment on your results as they compare to that of your partners.