Physics 233 **Lab 4**
September 2011 **Wave Optics**

Goals

- Observe two-slit interference, one-slit diffraction, and diffraction by a circular aperture with light.
- Measure the width of a hair and the radius of red blood cells using a laser.
- Get practice describing procedures in your lab notebook. (You will get to decide on some details.)
- To practice writing the theory section of a lab report.

Reading:

- Section 3.3 (The Theory Section) of the lab reference manual.
- Review chapter Q2
- Babinet's principle: The diffraction pattern for an opening is the same as the pattern for an opaque object of the same shape that is illuminated in the same manner, except for the intensity of the central spot. This principle can be useful for making measurements of very small objects. For example, a circular hole and a sphere of the same size will produce the same diffraction pattern. The corona, a ring that is sometimes seen around the sun or moon, is caused by diffraction of light by small particles in the atmosphere. Smog particle sizes can be remotely determined from measurements of the corona.

Pre-Lab Problems: (do all in your notebook, but also submit / check your answer to #3 in WebAssign)

1. Sketch (and label) the patterns resulting from light passing through a single slit and through a double slit. What is the main difference between these patterns?
2. When a hair is placed in a laser beam, will the resulting pattern be like that from a single slit or a double slit? Explain.
3. For the double slit experiment, what quantities must you measure to determine the wavelength? Explain how you will calculate the wavelength from the measured quantities. Also, write an expression for the uncertainty of the wavelength in terms of the uncertainties of the measured quantities. (Hint: Use the small angle approximation to simplify your work.)

Equipment:

Diode laser, slides with various apertures (the uncertainties in each dimension is ±0.005 mm), meter stick, ruler

Caution: Do not look into a laser beam because eye damage is likely to result. Also, avoid looking at reflections from shiny surfaces like the slides.

Lab Procedure: Be sure to describe exactly what you did in your lab notebook.

- Shine the laser beam through a double slit and place a screen far enough away that the interference pattern is easy to view. Make the measurements necessary to determine the wavelength of the light. (Hint: To get an accurate result, do not measure the very small distance between adjacent features on the interference pattern. Instead, measure the distance between features that are farther apart.)
- Shine the laser beam through a single slit and place a screen far enough away that the diffraction pattern is easy to view. Measure the width of the central bright fringe, which is defined as the distance between the centers of the dark fringes on either side of it, and any other relevant data.

- Shine the laser beam through the larger of the two circular apertures and place a screen far enough away that the diffraction pattern is easy to view. Measure the diameter of the central bright region, which is defined as the diameter of the dark ring around it, and any other relevant data.
- Use the laser to produce a diffraction pattern with one of your hairs. Make the measurements necessary to determine the width of your hair.
- Use the laser to produce a diffraction pattern with a slide that has dried blood on it. Wet blood is considered a biohazard, so do not use your own blood! Move the slide around to find an area where the blood is thin to get the best results. Make the measurements necessary to determine the diameter of a red blood cell.

Post-Lab Assignment:

1. Write the theory section of a lab report for all parts of the lab that you performed. You should've worked out the theory for one part in the pre-lab, but the other parts are slightly different! This should be typed.
2. Determine the wavelength of the laser using the data for the double slit. Be sure to calculate the uncertainty, too. (Hint: You should have a pretty good idea what the wavelength is in advance.)
3. For the single slit, calculate the theoretically predicted width of the central bright region and its uncertainty. Compare the theoretical value with your measurement of the width. Considering the uncertainties, are they consistent?
4. For the circular aperture, calculate the theoretically predicted diameter of the central bright region and its uncertainty. Compare the theoretical value with your measurement of the diameter. Considering the uncertainties, are they consistent?
5. Determine the thickness of the hair and the diameter of a red blood cell. Be sure to calculate uncertainties, too.