DIVFRACTION: PUZZLES TO SOLVE

OBJECTIVES: To use the diffraction of light to solve four puzzles:
1. Find the wavelength of a red semiconductor laser
2. Find the diameter of a circular aperture
3. Find the width of a single slit
4. Find the width of a strand of your hair

You can only use the following equipment:
- HeNe laser (\(\lambda = 632.8\) nm)
- Diffraction grating with a grating constant of 600 lines/mm
- Meter stick
- Ruler
- Tape
- Assorted stands and mounts

THEORY: The equations describing the diffraction patterns for a grating, circular aperture, and slit are summarized below:

**Grating** (with slit separation \(d\))
The maxima in the pattern occur at angles \(\theta\) given by
\[ d \sin \theta = m\lambda, \quad m = 0, \pm 1, \ldots \]
where \(m\) is the order number.

**Circular Aperture** (of diameter \(D\))
The first minimum in the pattern occurs at an angle \(\theta\) given by
\[ D \sin \theta = 1.22\lambda. \]
If the small angle approximation is valid, then
\[ \sin \theta \approx \tan \theta = y/L \quad \text{and} \quad y \approx 1.22\lambda L/D. \]
Note that \(y\) is the radius of the Airy disk (the central bright disk).

**Slit** (of width \(a\))
The minima in the pattern occur at angles \(\theta\) given by
\[ a \sin \theta = m\lambda, \quad m = \pm 1, \pm 2, \ldots \]
If the small angle approximation is valid, then
\[ \sin \theta \approx \tan \theta = y/L \quad \text{and} \quad y \approx m\lambda L/a. \]
PROCEDURE: Work with your group and solve the four puzzles! Be sure to document how you solved the puzzles. Reasonably estimate how well you trust your values, paying attention to measurement uncertainty.

REPORT:
Report the four sought after quantities in the following units:
1. wavelength of red semiconductor laser [\(\mu m, \text{nm}, \& \lambda\)]
2. diameter of circular aperture [mm & \(\mu m\)]
3. width of single slit [mm & \(\mu m\)]
4. width of strand of your hair [mm & \(\mu m\)]

Report the uncertainty in each value. Your score for this lab depends on how close your values are to the quoted values, the procedure that you followed, and your estimation in the uncertainty of each value.