Measuring Your Hair

Overview: Do you have thick or thin hair? Let's find out using a laser to measure the width of your hair and a little knowledge about diffraction properties of light. (Since were using lasers, make sure you're not pointing a laser at anyone, any animal, or at a reflective surface.)

What to Learn:

Materials:

- a strand of hair
- laser pointer
- tape
- calculator
- ruler
- paper
- clothespin

Experiment:

1. Tape the hair across the open end of the laser pointer (the side where the beam emits from)
2. Measure 1 meter (3.28 feet) from the wall and put your laser right at the 1 meter mark.
3. Clip the clothespin onto the laser so that it keeps the laser on.
4. Where the mark shows up on the wall, tape a sheet of paper.
5. Mark on the sheet of paper the distance between the first two black lines on either side of the center of the beam.
6. Use your ruler to measure (in centimeters) to measure the distance between the two marks you made on the paper. Convert your number from centimeters to meters (For me, 8 cm = 0.08 meters.)
7. Read the wavelength from your laser and write it down. It will be in "nm" for nanometers. My laser was 650 nm, which means 0.000 000 650 meters.
8. Calculate the hair width by multiplying the laser wavelength by the distance to the wall (1 meter), and divide that number by the distance between the dark lines. Multiply your answer by 2 to get your final answer. Here's the equation:

Hair width = [(Laser Wavelength) x (Distance to Wall)] / [(Distance between dark lines) x 0.5]

In the sample from the video, the wavelength was 650 nm = 0.000 000 650 meters, the distance from the wall was 1 meter, and the distance between the dark lines was 8 cm = 0.08 m, giving a hair width of 0.000 0162 5meters, or 16.25 micrometers (or 0.000 629 921 26 inches).

Measuring Your Hair Data Table

Laser Wavelength (λ): _____ (nm) Distance to Wall: _____ (in meters)

Hair Owner Name and Hair Type *(straight, curly…)*	**Distance Between Dark Lines** *(cm)*	**Calculated Hair Width** *(μm)*

Reading

This experiment works by scattering the laser light on the hair. The scattering creates a diffraction pattern that looks like a line of lightness with dark areas. By measuring the distance the laser and hair are from the wall and also how far away the dark spots are, you can calculate the hair width using a couple of simple equations.

When light passes by the hair, it diffracts, or bends. The light bends around the hair, and each side of the hair is hit with light that bends differently, so we say that there are two points of light (one on either side of the hair). When they expand out to the wall, they are actually cone-shaped and they begin to interfere with each other. When the light is "in phase", they constructively interfere (shown by bright spots of light), and when they are out of phase by 180 degrees, they destructively interfere, when by dark spots.

According to *Babinet's Principle,* the hair will be identical to t two slits spaced the same distance apart as the width of the hair (you'll learn more about this in college), and using the small angle approximation with your trigonometry equations, you can determine the formula for hair width to be:

Hair width = [(Laser Wavelength) x (Distance to Wall)] / [(Distance between dark lines) x 0.5]

If you rotate the hair a little under the tape of the laser beam, you'll find that curly hair gives a wider range of measurements, meaning that it has a more oval cross section, and straight hair is more round. How do you think you could modify the experiment to measure the sizes of other small objects, like blood cells or pollen?

Exercises

1. Which light source gave the most interesting results?
2. What happens when you aim a laser beam through the diffraction grating?
3. How is a CD different and the same as a diffraction grating?
4. Why does the feather work?

Answers to Exercises: Measuring Your Hair

1. Which light source gave the most interesting results? (answers vary)
2. What happens when you aim a laser beam through the diffraction grating? (it shows multiple dots all along the same plane.)
3. How is a CD different and the same as a diffraction grating? (A CD has little bumps that act like a diffraction grating, and different colors are bent at different angles when white light hits it, making a rainbow of colors.)
4. Why does the feather work? (A feather has little microscopic hairs that bend the light when it passes through them, acting like a diffraction grating.)