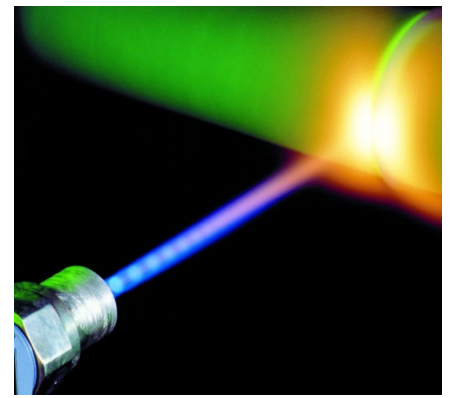


Student Worksheet for Ep. 13: Lasers

Overview: Scientists use lasers for cutting, melting, illuminating, measuring, communicating, and more. Lasers are monochromatic (only one color) and coherent, meaning that all the light is in phase with each other. Laser light is different from your standard light bulb, which is made of many colors and not in phase.



What to Learn: You can't just shine a flashlight through a lens and call it a laser, because the way a laser generates light is what makes it a laser in the first place. The word LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. Lasers are optical light that is amplified, which means that you started with one photon, and you ended up with two. *Radiation* refers to the incoming photon. It's a word that has a bad connotation to it (people tend to think all radiation is dangerous, when really it's only a small percentage that is). So in this case, it just means light in the laser. The incoming photon radiation starts the process of *stimulated emission* (when the electron jumps between energy levels and generates another photon). Put it all together and you have a LASER!

Lab Time:

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 we're using lasers, make sure you're not pointing a laser at anyone, any animal, or at a reflective surface.)

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 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:

$$\text{Hair width} = [(\text{Laser Wavelength}) \times (\text{Distance to Wall})] / [(\text{Distance between dark lines}) \times 0.5]$$

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 (<i>straight, curly...</i>)	Distance Between Dark Lines (<i>cm</i>)	Calculated Hair Width (μm)

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 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 the equation you used to find the width.