WHAT IS A LASER?

Ages 10-14, grades 5-8

Description:

In this activity, students will discover how lasers work and what makes a laser different from a flashlight.

Materials

- Red laser pointer
- Flashlight (old fashioned bulb or a single white LED)
- Meter stick
- Diffraction grating. If you don't have one, use a recordable CD. Remove the metallic label by scratching it, then put tape over the scratch and pull sharply upward. The label should come off so that you can shine light through the clear CD.
- Piece of waxed paper

Inexpensive red laser pointers can be purchased online, at pet stores where they are known as “cat teasers” or at office supply or hardware stores. Be careful of lasers purchased on internet sites as some of these are well above legal output levels for laser pointers (5 mW). The flashlight should be single bulb; multiple bulb LED flashlights will not work.

Safety Note

Review laser safety instructions before handing out materials. Red laser pointers are generally low power and safe. Remind students that it is not safe to stare at ANY bright light as it could damage the sensitive sensors in their eyes. Keep the beams at table level or below.

Background and Misconceptions

The word “laser” is an acronym for ***L**ight **A**mplification by **S**timulated **E**mission of **R**adiation,* which refers to the way light is produced inside of a laser. Laser is never spelled with a "Z"!

There are dozens of different types of lasers but in general terms each has three components: a medium, a source of energy, and a resonator or amplifying cavity. The medium is a material (solid, liquid or gas) that can be excited to give light by a source of energy.

Energized atoms usually give off extra energy quickly in the form of light or heat. An ordinary light source, such as a light bulb, produces a range of wavelengths with each photons emitted at random times and heading random directions. In a laser, the process of giving off energy is controlled so only a very narrow range of wavelengths is produced.

Teacher Guided Questions to Inquiry

Use these questions to get students started on their own inquiry. The activities will further explain the differences between the light from a flashlight and that from a laser. An animated PowerPoint slide show of how a laser produces light is available at www.lasertechonline.org/What_is_a_laser.html

1. **What is a laser?** (A laser is a source of light. It may be low power like a laser pointer or it may be powerful enough to cut through metal. The light may be visible (the colors of the visible spectrum), or invisible infrared or ultraviolet.)
2. **What do you notice about lasers in movies or on TV?** (Student observations may include that laser beams seem to travel long distances without spreading. Lasers are often depicted as being immensely powerful weapons, even though many lasers have low power, like those in a CD or DVD player or the laser pointer used in these activities. Also laser beams are often shown glowing from the side of the beam, which only happens in a very dusty or foggy environment. Without something to reflect the light to your eyes, the beam cannot be seen from the side.)
3. H**ow is a laser pointer different from a flashlight?** (Observations may include: Laser pointer beams are brighter because the beam is "concentrated" into a small spot. Flashlight beams spread more widely. A laser pointer produces a single color spot while a flashlight produces "white" light.)

Guided Inquiry

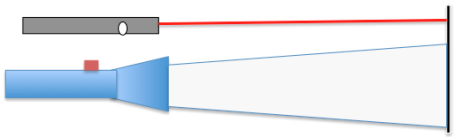
The properties of laser light arise from the way light is produced (stimulated emission in a reflective amplifying cavity) and will be demonstrated in the following three activities.

Activity 1: Flashlight and Laser Beams (Laser beams are directional)

Compared to ordinary light sources, laser beams do not spread as much as they travel. We say they do not *diverge* as much. To test this:

- Place the laser on a table near the edge and one meter from a wall. Measure the diameter of the laser spot on the wall. Record the size of the spot.
- Move the laser at least two meters from the wall and repeat the measurement.
- How much did the spot size increase?
- Repeat the procedure with the flashlight.

The laser light may be bright and difficult to measure and the flashlight spot will be a smudgy blob. Students will need to decide how best to measure. They should see that both beams spread but the flashlight spreads more.



Activity 2: Flashlight and Laser Colors (How many colors?)

Compared to ordinary light sources that are made up of many colors, laser beams are only one color (*monochromatic)*. To test this:

- In a darkened room, shine the laser through a diffraction grating or CD with the label removed so the spectrum is displayed on a nearby wall or table top. Record the colors.
- Repeat with the flashlight and again record the colors that are on displayed on the wall.

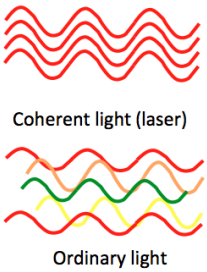
Students may see several spots from the laser but what is important that they are all the same color. Students may see spots with the flashlight too, but there are also rainbows, that is, white light is made up of many colors.

Activity 3: Blobs and Speckle (Coherent waves in step)

Though coherence is a complicated concept, students will be able to see the result of the laser's coherent light.

- In a darkened room, cover the end of the laser with wax paper and shine it on a piece of white paper about 15 cm away. The laser spot that is spread by the waxed paper will show small bright spots that appear to move as you move your head (*laser speckle*).
- Repeat with the flashlight. The flashlight spot will show little change and no “speckle.”

The monochromatic waves that make up a laser beam are orderly and stay in step (coherence) as they travel. That is shown by the mottled pattern of small bright and dark spots on the wall. The flashlight will not show any speckle because the chaotic multicolor waves are not coherent.



Analysis Question

What are the three properties of laser light?

- Laser light only slightly diverges (it does not spread much)
- Laser light is monochromatic (it is made of only one color)
- Laser light is coherent (the waves stay in step as they travel)