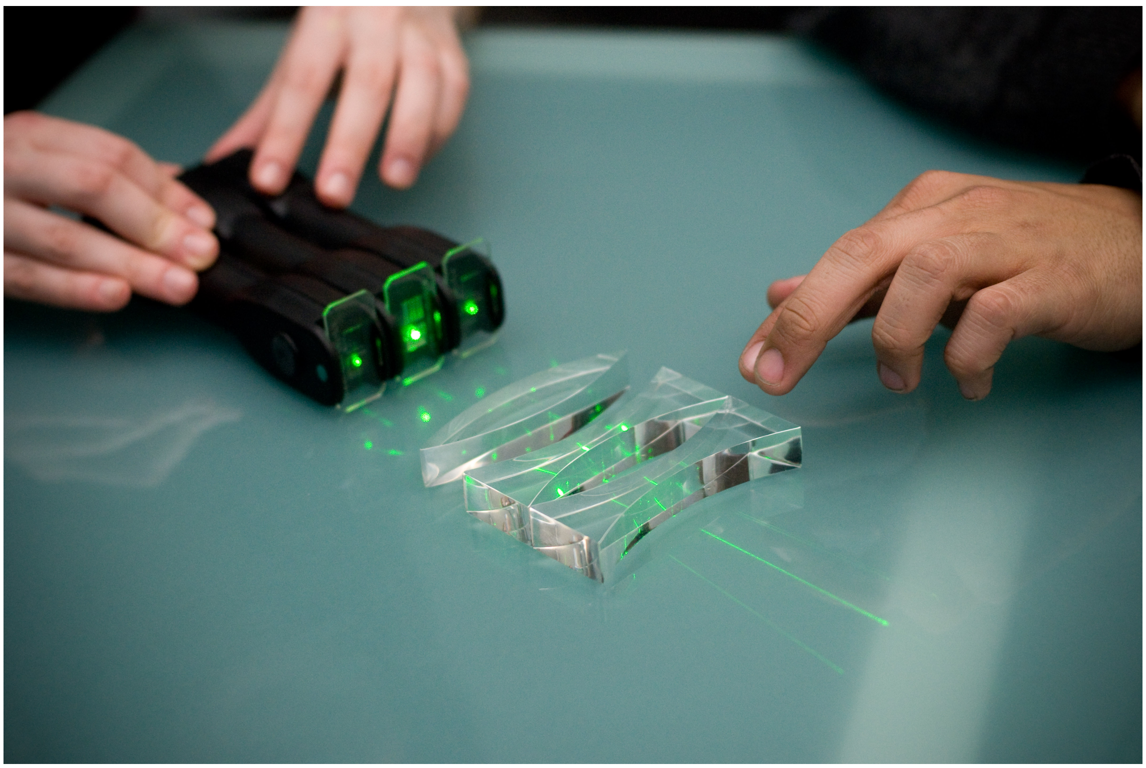
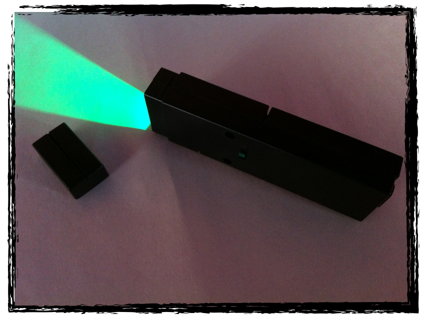
The Properties of LASER Light...

Monochromatic, Collimated and Coherent



LASER CLASSROOM™
BRINGING STEM TO LIGHT

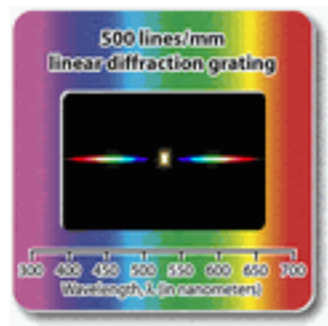
LASER Light 1: Monochromatic



By comparing the spectra of white light with colored LED light and LASER light, students observe that light emitted by a LASER is monochromatic, and consists of a single wavelength (color) of light.

Time: 30 minutes

Grades: 6-12



Materials

* A red, green and blue Light Blox with slit caps
* One red and one green LASER Blox
* Several Sources of whit Light (LED, Flashlight, room lights)
* One diffraction grating per student

Setting Up

1. Set up the LIGHT Blox at the front of the room, pointing towards the classroom so that students can see the light when you turn them on (later)
2. Set up lasers so that they are emitting light AWAY from students to project towards a blank wall when you turn them on (later)
3. Hand out one diffraction grating per student

Discussion and Background

Ask students to share their answer to the question: How is LASER light different from other light? What makes a LASER, a LASER?

Without commentary or correction, write students' responses on the board and leave them where they can see them. If you will be returning on another day to this class, record responses on a piece of paper as well.

Introduce the lesson by telling students that today, they will investigate one property of laser light. Do not tell them what it is. We will see if students can name it by investigating and observing.

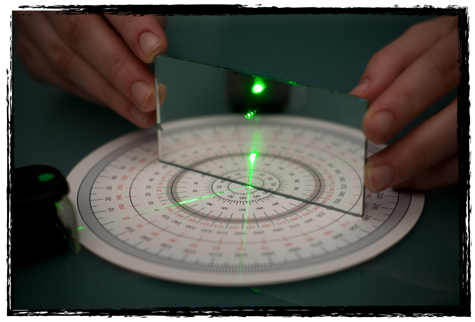
Investigating and Observing

1. Remind students that white light is made of “all” wavelengths of light – white light is what we see when those various wavelengths of light interact with each other.
2. Introduce the diffraction grating – explain that a diffraction grating separates the light we view through it to display a spectrum – a unique signature of the wavelengths included to make up the light we are looking at.
3. Demonstrate for students how to use the diffraction grating; hold the diffraction grating up to one eye and look towards a light source (NEVER directly at the sun or any LASER) – now look to one side to observe the spectrum.
4. Invite students to practice looking for spectra from the various “white lights” available – fluorescent bulbs, light bulbs, a flashlight.
5. Ask students to describe what they see – “a rainbow”. Ask them to tell you what colors they see, and in what order. Ask them to tell you whether or not the colors are in the same order for all the lights they look at or whether it varies. Be sure they arrive at the conclusion that violet, or purple is always closest to the light source.
6. Next tell students that they will observe the light spectra of various colors of LED’s. Turn on the Light Blox and ask students to observe that there is a red, a green and a blue Light Blox = red, green and blue LED.
7. Ask students to predict what they will see when they look at the LED/Light Blox. Will they see a spectrum? Or just one color? Is the LED made up of more than one wavelength, like white light, or just one? Invite one student who predicts they will see a spectrum to share their reasoning. Invite one student who predicts they will NOT see a spectrum to share their reasoning.
8. Without commentary or correction – invite students to see for them selves by using the diffraction grating to observe the LED light from the red, green and blue Light Blox. Students may need to move closer to see well.
9. Ask students to share their observations and explain that even a red, green or blue LED is made up of its own distinct spectrum of colors.
10. Finally, ask students to predict what they will see when they look at the green and red LASER light. Invite students to share their answers and their reasoning.
11. Turn on the lasers – pointing AWAY from the students, towards a blank wall.
12. Instruct students that they are NEVER to look directly at ANY LASER – EVER.
13. Tell students that they will observe the spectrum of laser by passing the laser through the diffraction grating.
14. Place a diffraction grating in front of each LASER and allow students to observe that while the grating is “separating the LASER light – there is only one color.
15. Invite students to share and speculate on what they see.
16. Ask – So… what is the special property of LASER light that we observed today?

ONE COLOR, ONE WAVELENGTH or MONOCHROMATIC.

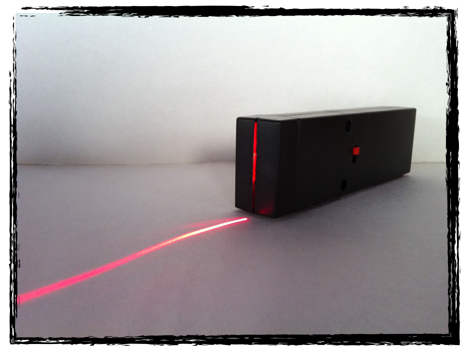
LASER Light 2: Collimated

By comparing LED light to LASER light, students will observe that LASER light is collimated (travels in parallel rays)



Time: 20-30 minutes

Grades: 6-12



Materials

- Green LASER Blox
- Red LASER Blox
- Green Light Blox with the slit cap removed
- Red Light Blox
- Ruler
- Plain, white paper

Discussion and Background

Tell students that they will be observing a fundamental property of LASER light today – a property that makes LASERs much more dangerous and powerful than the light they are familiar with – even when the LASER puts out very little power – like the ones you have with you (LASER Blox).

LASER light is collimated – rays of light are parallel to each other. Make a contrast with “ordinary” light, which spreads out or diverges, as it travels. This activity will demonstrate the effect of collimation.

Setting Up

1. Divide students into 4 groups
2. Give each group one light source (either a Light Blox or a LASER Blox), a ruler and a sheet of paper
3. While students are collecting data, draw the following chart on the board or on large white paper at the front of the room.

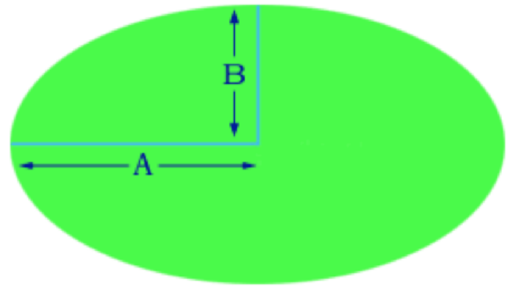
Student Data Sheet

LIGHT SOURCE	DISTANCE	AREA
Red LED	1”	
Green LED	1”	
Red LASER	1”	
Green LASER	1”	
Red LED	3”	
Green LED	3”	
Red LASER	3”	
Green LASER	3”	
Red LED	6”	
Green LED	6”	
Red LASER	6”	
Green LASER	6”	

Investigating and Observing

1. Tell students that they will be measuring the Area of light produced by their light source from 3 different distances: 1”, 3” and 6”.

2. Ask students to generate the formulas for area of
   a. a rectangle a=wh
   b. a circle: $A = \pi \cdot r^2$ or $A = \pi \cdot r \cdot r$
   c. an ellipse Area = Pi * A * B



3. Ask students to shine their light source at a plain piece
   to calculate the area of the “spot” of light from each distance

4. Invite one student from each group to come up and add their group’s data to the chart.

5. Ask the class – what do you notice? How is the LASER light different from the LED light? It is collimated!

LASER Light 3: Coherent

By comparing LED light to LASER light, students will observe that LASER light is collimated (travels in phase)

Materials

- Green LASER Blox
- Red LASER Blox
- Green Light Blox with the slit cap removed
- Red Light Blox
- Plain, white paper

Time: 20-30 minutes

Grades: 6-12

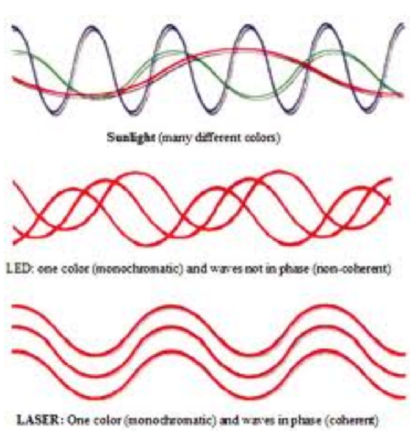
Setting Up

1. Divide students into 4 groups
2. Give each group one light source (either a Light Blox or a LASER Blox), a ruler and a sheet of paper

Discussion and Background

LASER Light is coherent – which means that it is “in phase or in step”. This means that all of the light waves’ peaks and valleys’ line up.

Draw a diagram on the board to demonstrate



Observing and Investigating

1. Ask each group to hold their light source very close to the paper at a small angle and observe what they see. Have them discuss among themselves and come to agreement and write down an observation.

2. Have groups switch light sources with another group… if a group has an LED, they should get a LASER … if they have a LASER, they should have an LED. Have students repeat step one with their “new” light source and compare.

3. What students should observe is a speckle pattern with the laser light and no speckle pattern with the LED light. They may need some guidance and/or to pass the light sources back and forth a few times to notice the subtle difference.

4. Explain that Light travels in waves – when those waves are in phase (coherent) they interfere with each other in a specific way. Coherent waves can cancel each other out (destructive interference) or amplify each other (constructive interference 0

5. A pattern of bright and dark spots (very very small) is produced by the coherent LASER light because of this interference – but that pattern is not produced by the LED light, because the LED light is not coherent, or in phase.