LASER CLASSROOM

Bringing STEM to light®

BIG IDEAS

- Demonstrate that LASER light is coherent by comparing the interference pattern of a red LASER pointer to that of LED light.

WHAT YOU'LL NEED

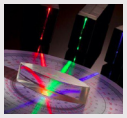
- 1 LED/Light BLOX: Red, Green or Blue
- Red & Green Laser Source
- A blank sheet of paper

RELATED PRODUCTS

Click the below to be taken right to the product page.

Red Laser Blox

Green Laser Blox



Light Blox

COHERENT LASER LIGHT

LASER light has three main properties that distinguishes it from normal, everyday light we come in contact with: it is monochromatic (Act 7), collimated (Act 8), and coherent. Here we will learn about the property of coherence.

LIGHT WAVES

A beam of light consists of a number of rays of light. Each ray of light can be represented as a wave, like a wave in the ocean, also called a transverse wave. When all the waves of light in a beam are in step, or in phase, we say the light is coherent.

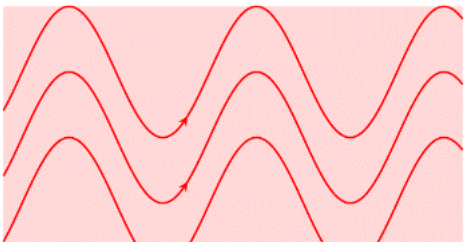


Figure 1: Coherent Light

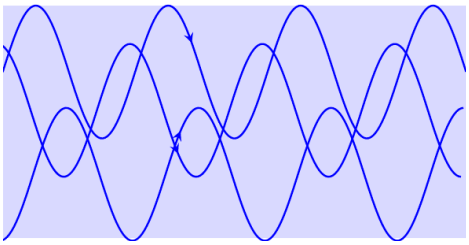


Figure 2: Incoherent Light

If two rays of light are in step or in phase, it means their crests (and troughs) sync up. *Figures 1 and 2* show the difference between coherent and incoherent light. In *Figure 1*, you can see the peaks of the waves are all aligned, forming a coherent beam of light. In *Figure 2*, the peaks are randomly aligned - this is an incoherent beam of light.

DIFFUSE REFLECTION

The law of reflection states that angle of incidence is equal to the angle of reflection. When a beam of light is reflected off a smooth surface, such as in *Figure 3*, all the rays have the same angle of incidence, and hence all move off at the same angle of reflection as well. This is called specular reflection.

If a beam of light is shone on a coarse or uneven surface, however, the rays are all reflected at different angles, as shown in *Figure 4*. This is called diffuse reflection.

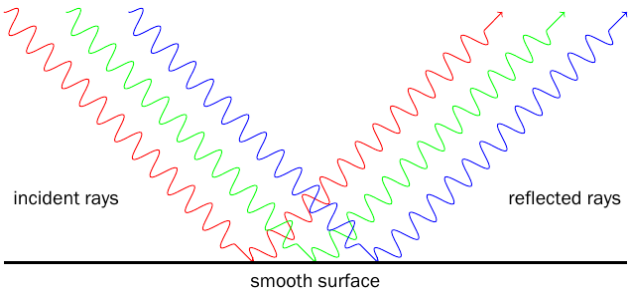


Figure 3: Regular Reflection

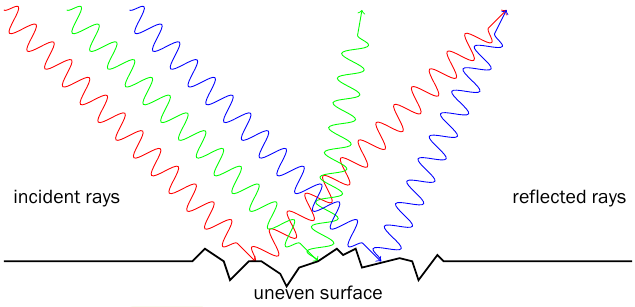


Figure 4: Diffuse Reflection

INTERFERENCE AND SPECKLE PATTERNS

When two rays of light meet, they can interact with each other through a process called interference. . Thinking of the light as waves in the ocean or on a pond, if two crests meet, constructive interference occurs, and the wave gets bigger; the resulting ray is amplified. If a crest and a trough meet, the waves experience destructive interference, and the resulting wave is diminished or cancelled out.

Remembering the concept of diffuse reflection mentioned earlier think of many waves bouncing off a rough surface. When an incoherent beam of light is diffusely reflected, the rays of light cross each other and interfere, but the results are completely random. So any changes are smeared out and the brightness of the beam of still looks the same everywhere.

But when coherent light is diffusely reflected the interference is more regular. This is because the incident light rays are in phase – the way the crests and troughs of the waves meet up creates a noticeable pattern when the rays are reflected. The pattern that results is called a “speckle pattern”. The reflected light beam appears to be covered in dark spots - these are areas of destructive interference - while the bright patches are areas of constructive interference.

COHERENT LIGHT IN REAL LIFE: MONITORING BLOOD FLOW

The shape of thespeckle pattern produced by a coherent source of light is determined by the roughness of the surface off of which it reflects. If the surface changes, so does the speckle pattern produced – when a speckle pattern changes with changes in the rough surface this is called dynamic speckle.

Dynamic speckle is used in medicine to monitor blood flow in patches of skin. As blood flows just under the surface of the skin, it causes the skin to move. By shining a coherent light source on the patch of skin and watching the speckle pattern change, doctors can judge how quickly blood is flowing in that area.

ACTIVITY SHEET: COHERENT LASER LIGHT

This activity will explore the coherence of LASER light.

Switch on the Light Blox and hold it close to the paper, at a small angle. The light should stretch out in front of the Light Blox in an ellipse.

Take a close look at the light. What do you observe? Is there anything unusual about the light?

Now, hold the LASER pointer the same way, and switch it on. The LASER light should form a long ellipse. What do you observe about the LASER light? Is there anything unusual happening? How is it different to the light from the Light Blox?

You'll notice that the LASER light isn't consistent in brightness, like the light from the Light Blox. The LASER light is covered in tiny dark spots. This is the speckle pattern of the LASER light.

You might have to move between the Lazr finger and the LASER pointer a couple of times before you see the difference in the light - keep going until you see it!

Now that you know what the speckle pattern looks like, move the LASER slowly while shining it on the paper. What do you observe about the speckle pattern? Why do you think this happens?

The surface of the paper may look smooth, but it is actually uneven as so as you move the laser, the part of the paper you are hitting with the light changes and this changes the speckle pattern!

See how many other coarse surfaces you can find to observe the speckle pattern on. The skin on the inside of your elbow is a good one. Does the speckle pattern change? How so?

The speckle pattern will be different for every surface you shine the LASER on! In the crook of your elbow, you might observe more very bright spots than on the paper.