Laser Pointer Safety

HSE Guide

Nowadays, the use of laser pointers that operate in the visible region (400 to 700 nm) of the electromagnetic spectrum is widespread. These pointers are typically used for presentations (classroom, meetings, conferences, business presentations, etc.) but also for aligning other lasers, laying pipes in construction, etc.

The power emitted by these laser pointers ranges from 1 to 5 mW. They are widely available at electronic or online stores. At $20 or even less, laser pointers are in the price range of other electronic toys and have been treated as such by many parents and children. **Laser Pointers are not toys!** Although most of these devices contain warning labels, as required by FDA regulations, many have been erroneously advertised as "safe".

Laser Pointer Use

Laser pointers use diode lasers as the optical source. Nowadays, these diode lasers can emit over a wide range of wavelengths from blue to green to red. The first laser pointers used diode laser emitting in the red (690 nm) but because the human eye is not very sensitive to these wavelengths an output power of 5 mW was needed (Figure 1). According to the American National Standard for Safe Use of Lasers (ANSI Z136.1) these diode lasers correspond to Class 3R lasers and can be hazardous if viewed even for a very short time.

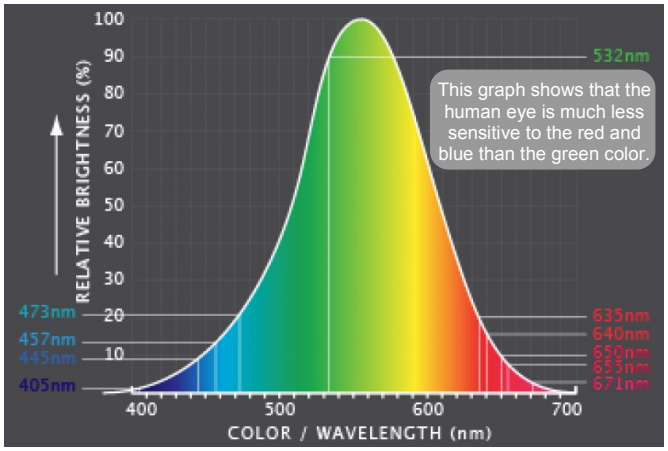

Figure 1. Human eye relative sensitivity to color. For a same output power a green laser pointer will appear much brighter than a red one.

The main components of a laser pointer are shown in Figure 2 and include:

- Batteries
- Circuit board – circuitry that make the laser pointer function.
- Diode laser – emitting at the desired wavelength.
- Collimating optics – usually lenses that ensure the beam at the pointer exit remains of small size over a long distance.
- Diode assembly – Plastic holder that holds the laser diode and collimating optics together.
- Case – external part of te laser pointer which also contains a switch, labels, etc.

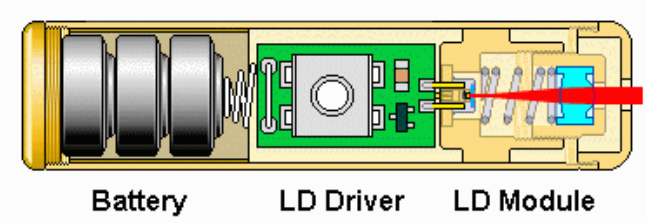

Figure 2. Typical red laser pointer.

Laser pointers are widely used for:

- Educational and business presentations.
- Industry to accurately measure distances, or for levelling.
- Entertainment – in clubs and parties to create special effects.

Dangers of Laser Pointer?

The main hazards from laser pointers are:

- Eye Injury
- Incorrect power and class rating
- Some old style green laser pointer
- Malicious use

Eye Injury

Laser pointers commonly used are either Class 2 (if power is less than 1 mW) or Class 3R (if power is less than 5 mW). According to American National Standard for Safe Use of Lasers (ANSI Z136.1) Class 2 lasers are safe if exposure to the eye is less than the aversion response or blink reflex (about 0.25 seconds). However, retinal injury is possible with a Class 2 laser if a person deliberately

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overcomes his/her natural aversion response by intentionally looking at the beam. Class 3R lasers can be hazardous even if viewed for a very short time. Class 2 and 3R lasers are not a skin hazard. **Therefore, the major potential hazard from pointers is limited to the unprotected eyes of individuals who look at the direct beam emitted from the laser**. The natural aversion response or blink reflex (about 0.25 seconds) of the eye from the bright laser light normally limit exposure to a safe level for those devices. However, over the past decade and with the wide availability of such devices, there has been a large increase in laser eye injury especially in children who are given laser pointers as toys.

Incorrect Power or Class Rating

Class 2 lasers shoud have a maximum power of 1 mW; while Class 3R laser should have a maximum power of 5 mW in the visible wavelengths (400-700 nm) and 2 mW in the infrared wavelength (>700 nm). A study performed by the National Institute of Standards and Technology (NIST) in 2013 to evaluate the safety of mainly Class 3R laser pointers showed that 90% of green pointers and 44% of red pointers were out of compliance with US Regulations. They also found that red and green pointers both emitted more visible power (>5 mW) than allowed by the regulations for the laser pointers to be classified as Class 3R. This means that these laser pointers are more hazardous than advertised.

Old style green laser pointers

The beam from green laser pointers appears very bright compared to that of red laser pointers because the human eye sensitivity is best around the green wavelengths (Figure 1). These pointers were preferred because they were easier to see. The design of these pointers is more complex than the typical red emitting laser pointers. They use a technique called diode pumped solid state frequency doubled whereby the green light is generated through a multi-step process. It begins with a diode emitting at 1064 nm (infrared). The 1064 nm beam then travels through a non-linear crystal which converts the 1064 nm (infrared) into 532 nm (green) wavelength. Collimating optics with special coating, which stops the infrared beam, are added at the end of the pointer. A schematic of such pointer is shown in Figure 3.

Figure 3. Schematic of a green laser diode pointer.

Because the green wavelength is obtained from conversion of an infrared wavelength these pointers must have good quality optics to ensure that the infrared wavelengths do not exit from the pointer. Indeed, infrared light emitted between 700 -1400 nm cannot be detected by the human eye but can easily cause irreversible damage to the eye (affecting the retina). The study performed by NIST in 2013, also demonstrated that green pointers often emitted unacceptable levels of infrared light which makes them extremely dangerous even if the beam is viewed unintentionally. This is often the case in cheap green pointers.

Some modern green laser pointers do not use this technique but a laser diode which emits in the green directly. These are safer since they do not emit infrared lights but it is very difficult to know which one uses a laser diode directly emitting in the green and which one uses the old fashioned conversion system.

Malicious Use

In recent years, safety professionals have also highlighted dangers related to secondary effects. These are effects experienced following exposure to laser light while performing critical activities such as driving or piloting an airplane/helicopter, etc. These effects, which are called glare, flash-blindness, and afterimage, do not cause permanent eye injury as they last only a few seconds or minutes. However, if someone shines laser pointer

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at a driver or pilot, s/he may lose control due to either a split second visual effect or a psychological effect (startle or panic), and the consequences could be dire.
The secondary effects observed are:

Afterimage: The perception of light, dark, or colored spots after exposure to a bright light that may be distracting or disruptive. Afterimages may persist for several minutes.

Flash-blindness: A temporary vision impairment that interferes with the ability to detect or resolve a visual target following exposure to a bright light. This is similar to the effect produced by flashbulbs, and can occur at exposure levels below those that cause eye damage. This impairment is transitory, lasting seconds to minutes depending upon the lasers light exposure level and time, the visual task, the ambient lighting and the brightness of the visual target.

Glare: A reduction or total loss of visibility, such as that produced by an intense light source (e.g. oncoming headlights) in the central field of vision. These visual effect lasts only as long as the light is actually present affecting the individual's field of vision. Visible laser light can produce glare and can interfere with vision even at low energies well below those that produce eye damage.

In April 2019, Saudi Arabia's Council of Ministers issued Resolution No. 4444 of 4 Shaban 1440 (corresponding to 9th April 2019), regulating public behavior and public decency. This includes: "shining laser pointers into people's eyes". Violators may receive a fine of maximum of 5,000 SAR (first offense).

Safety Precautions

Laser pointers are very valuable tools which should be used with caution. Always select a safe laser pointer:

- Purchase a Class 2 pointer from a reputable manufacturer.
- Ensure the pointer has clear warning labels. Many do not have warning labels and may be more powerful than expected.
- Ensure you can switch off the laser emission very quickly (e.g. by releasing button).

Below are a few safety precautions which will ensure the safe use of laser pointers:

- Never shine a laser pointer at anyone.
- Do not allow children to use a pointer unsupervised. Laser pointers are not toys.
- Do not point a laser pointer at mirror-like surfaces (e.g. glass window, shiny screen, etc.). A reflected beam can act like a direct beam on the eye.
- Switch the laser pointer off when not in use, if possible, remove the batteries.

Additional Information

Saudi Arabia study: "Handheld blue-light lasers can cause macular hole in retina"

Laser pointer and children's eyes

Laser pointer safety website

Laser pointer safety – Harvard University