The Safe Use of Lasers

Introduction

The use of lasers in the classroom has significant educational value, and the safe use of lasers in the classroom is possible. With proper usage, no damage to the eyes should occur. However, when lasers are abused, such as directly pointing a laser into the eye, damage may occur.

Position Statements on Laser Pointers

The Department of Energy has issued a safety and health note concerning the safe use of common laser pointers. They point out that despite their small size, these pointing devices can cause eye damage if used improperly. The potential hazard is limited to looking directly into the laser beam with unprotected eyes. No hazard to the skin exists from laser pointers. Users of laser pointers should never aim the pointer into the audience.

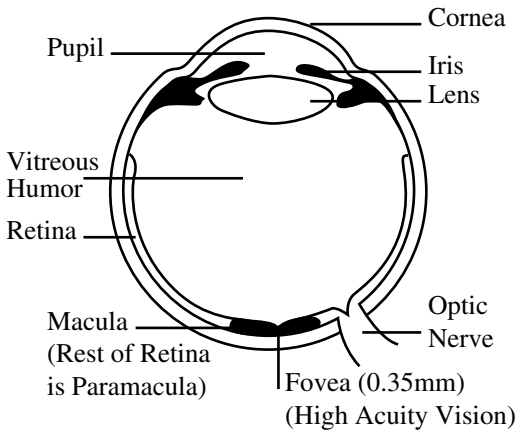
The Food and Drug Administration has issued a warning on the misuse of laser pointers. They state that the light energy from Class 3a *(see Laser Classification section below)* laser pointers, if aimed directly into the eye, can be more damaging than staring directly into the sun. They concluded that injuries associated with these laser pointers appear to be related to improper use. They say that these products are generally safe when used as intended by teachers and lecturers to highlight areas on a chart or screen.

The *World Heath Organization* considers the professional use of a Class 1 or 2 *(see Laser Classification section below)* laser pointer to be justified. The use of Class 3b laser pointers up to 5 mW may be justified for some applications in the work-place where the user has received adequate training.

The *American Academy of Ophthalmology* asserts that it is theoretically possible to produce retinal damage by staring at a Class 3a laser beam for more than 10 seconds, so it is important to keep laser pointers away from infants and children.

Laser Hazards—Eye Damage

The principal region of concern for eye damage for low- to medium-power lasers is the retina. The retina is most senstive to visible light wavelengths between 400 and 700 nm. When ordinary light enters the eye, the light is converted into a chemical signal by the retina that is eventually sent to the brain for processing. When excessive light, such as the light from a laser beam, enters the eye, it is focused on the retina and may heat the retinal tissue.



The temperature rise of the retinal tissue depends on the energy of the light, the size of the spot exposed to the laser beam, and the length of time the tissue is exposed to the light. When the retinal tissue is heated excessively, proteins in the tissue are denatured and lesions may form. How serious are the lesions that may form? A minimum lesion occurring in the paramacular area is undetectable. More serious lesions may cause a temporary or permanent loss of vision. The time taken to recover from these effects varies from person to person.

Although the risk of permanent eye injury from a laser pointer may be small, a person receiving even a small eye exposure may experience a bright flash that is likely to cause distraction, temporary loss of vision in the affected eye, and possibly after-images. The time taken to recover from these effects will vary for different people and will depend on the light level at the time of exposure. Medical attention should be sought if after-images persist for hours, or if disturbance in reading vision is apparent.

Laser Classifications

Because the power of a laser is one of the most important factors determining the potential for injury, it is important to know the power of the laser being used so that proper precautions may be taken. Lasers are classified by the *American National Standards Institute*. The laser classification scheme is based primarily on the ability of the laser beam to cause biological damage to the eye or skin during intended use. In addition, classification of continuous wave lasers requires

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consideration of the wavelength and/or wavelength range, the average power output, and the length of exposure intended for proper use of the laser.

Class 1 lasers are considered to be incapable of producing damaging levels of radiation and are therefore exempt from control measures. **Class 2** lasers are low-power lasers whose output is in the visible portion of the spectrum (400–700 nm). Eye protection from Class 2 lasers is provided by the blinking response. **Class 3** lasers are medium-power lasers. A Class 3 laser may be a hazard if viewed directly; however, there is usually no hazard associated with indirect viewing (diffuse reflections). Most inexpensive laser pointers are Class 3 lasers. **Class 4** lasers are high-power lasers. They are hazardous to the eye and skin from direct viewing or contact and may be a hazard to the eye and skin through indirect viewing (diffuse reflections). Class 4 lasers can be fire hazards. Class 4 lasers may also produce air contaminants and hazardous plasma radiation.

Class	Hazard	Power	Lasers Sold by Flinn	
Class 1	No eye damage.	≤0.4 μW		
Class 2	Hazard if stared at for longer than 0.25 seconds.	≤1 mW	AP9246	0.8 mW, He-Ne, Unmodulated
Class 3	Hazard if viewed directly. Usually no hazard for indirect viewing.	≤500 mW	AP8934	Laser Pointer
			AP4667	Pocket Laser Pointer
Class 4	Hazard if viewed directly or indirectly.	≥500 mW		

Table 1. Hazards associated with each class of lasers and the Flinn lasers that fall into each class.

Maximum Permissible Exposure Levels

Maximum Permissible Exposure (MPE) levels have been developed by the *American National Standards Institute* to determine the lowest theoretical laser power that may be hazardous to eyes. The MPE values are below known hazardous levels. Exposure to levels at the MPE values given may be uncomfortable to view with unprotected eyes or feel upon the skin. Thus it is a good idea to maintain exposure levels as far below the MPEs as possible.

Industrial hygienists calculate MPE values using a set of standards and fairly complex equations. MPEs are based on the assumption that the eye is a perfect optical instrument, the light beam will be focused onto a very small spot within the retina (10 microns), and the eye will blink within 0.25 seconds of being irradiated with a laser or bright light. The MPE for direct viewing is calculated to be 1 mW. Therefore, anything greater than a 1 mW laser has the potential to cause damage to an unprotected eye, especially if the eye is exposed to the laser for more than 0.25 seconds.

In reality, the eye is not a perfect optical instrument and normal muscle movement will increase the size of the spot on the retina. This increases the effective spot to more like 200 microns in most real-life situations. The increased spot size spreads out the energy from the light, decreasing the possible damage to a single spot. In this case, hazardous heating of the retinal tissue occurs with direct viewing at approximately 20–30 mW.

If viewing a laser indirectly, such as through peripheral vision, the potential damage is much less. The MPE for indirect viewing is 160–634 mW depending on the distance to the laser beam and the reflectivity of the medium.

Conclusion

With proper use of lasers, including laser pointers, no damage to the eyes should occur. It is when lasers are used improperly, such as pointing them directly into an unprotected eye, that damage may occur.

References

American National Standard for Safe Use of Lasers; Standard Z136.1; Laser Institute of America: Orlando, FL, 1993.

Laser Pointers Not Toys Says American Academy of Ophthalmology; http://www.eyenet.org/, 1998.

Laser Teaching Supplement; Metrologic Instruments: Blackwood, NJ, 1993; pp 2–10.

Press Release; *FDA Issues Warning on Misuse of Laser Pointers;* http://www.dhhs.gov/, Dec 18, 1997.

Safety & Health Note; *The Safe Use of Common Laser Pointers;* U.S. Department of Energy; DOE-EH-0393—Issue No. 94-10, 1994.

World Health Organization/Fact Sheet No. 202; *Health Risks from the Use of Laser Pointers;* http://www.who.ch/, 1998.

Crim, F. F.; Notes from Laser Safety Course; University of Wisconsin—Madison; Madison, WI, 1995.

Lasers are available from Flinn Scientific, Inc.

Catalog No.	Description
AP9246	Laser, 0.8 mW, Unmodulated, He-Ne
AP8934	Laser Pointer
AP6492	Green Laser Pointer

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.