LASER SAFETY PROGRAM

Laser Safety Document

For Youngstown State University

Introduction

The University Subcommittee on Laser Safety has developed this document to assist faculty, staff and students in the safe use of lasers on the YSU campus. The Subcommittee does not intend to assume the role of a law enforcement body but instead would like to offer help to all faculty that require lasers in their work. The Subcommittee notes that along with the increased use of lasers in research and demonstration, a similar increase in injuries and lawsuits has occurred. It becomes prudent for a person in charge of the use of a laser system to ask the following question. "Has there been sufficient training (and documentation of such training) that an accident should not occur involving the use of my laser system?" Be advised when an injury occurs involving a laser, lawsuits name institutions, manufacturers *and* faculty members. Members of the Laser Safety Subcommittee use lasers too. It is the safe use of lasers the Subcommittee would like to maintain. The use of any laser or laser system is classified more hazardous than American National Standards Institute (ANSI) class 2B must be reported to the University Laser Safety Officer (LSO). The Director of Environmental and Occupational Health and Safety will assume the role of the LSO and can be contacted at extension 3700.

Goals

The specific goals of the Subcommittee are:

- Promote the use of lasers in research, classroom demonstration and public shows on the campus of Youngstown State University
- Encourage the faculty to provide opportunities for students to use lasers and laser systems in their class work and investigation of research projects
- Outline the accepted standards for the safe use of lasers
- Help ensure safe practice in the use of lasers on the campus at YSU
- Help educate the University community on the safe use of all types of lasers
- Assist the Laser Safety Officer on questions of hazard determination and safe use of lasers on the YSU campus

The members of the Subcommittee welcome any questions about the use of lasers anywhere on campus. The Subcommittee will also investigate any question regarding the safe use of laser systems and assist the faculty or staff member liable for its safe use.

Laser Classification

The following guidelines are not meant to be a complete description but simple a brief guide for some systems commonly in use. Most users of specific hazardous laser systems have the expertise to determine safe use practices. A determination of the classification for any particular laser system can be obtained from the Subcommittee upon request.

Class 1: This class denotes lasers or laser systems that do not, under normal operating conditions, pose any hazard. Any completely enclosed laser (such as those found in CD ROMs, fiber optic systems or laser printers) cannot have emissions exceeding the maximum permitted exposure (MPE) under any conditions are class 1 systems. However, the repair of such laser systems may be hazardous if such repair involves the use of the laser with the enclosure removed or partially removed. No external labels are required for this class but internal warning labels reside beneath cover panels may be necessary to assure safe servicing.

Class 2A: This class of lasers includes low power visible lasers (0.4 to 0.7µm) that will not produce a hazard if the beam is viewed directly for periods less than 1000 seconds (about 16 minutes). Very few lasers fall within this class. Any visible laser with a total output power less than 1 milliwatt but greater than a few micro watts may be Class 2.

Class 2: This class of lasers is visible lasers that are intense enough that the entrance of the beam into a human eye will cause the normal aversion response. Additionally, the normal aversion response time of .25 seconds ensures that no permanent damage will occur. However, as is possible when viewing the sun, it is possible to overcome this normal aversion response with resulting damage to the eye.

Class 3A: This class of lasers includes those emitting ultraviolet or infrared light as well as those emitting visible light. All systems falling within the Class 1 AEL (Allowed Exposure Level) with laser output between .18µm and 1mm fall into this class.

Class 3B: This class of lasers includes the same laser output spectrum as class 3A but increases the output level to that of Class 2 AEL.

Class 4: Any laser that exceeds the Class 2 AEL falls within this class. Most every laser that produces an excess of .5 Watts is in this class.

Laser pointers are becoming more common in classroom use and require some safety precautions also. Most pointers are Class 3A laser devices. Please refer to appendix A on the safe use of laser pointer.

The hazard evaluation extends beyond the hazards associated with the laser output alone. Many laser systems also have associated risks involving chemical dyes, radioactive isotopes, high voltage, burns, laser generated air contaminants or primary and secondary x-ray emission. The LSO in conjunction with the Laser Safety Subcommittee can assist any campus user in assessing the risks for their laser systems.

Safe Practice Documents

To promote the safe use and repair of all lasers on campus, it is necessary each faculty member or department head in charge of the use or repair of a laser system submit a proposal to the LSO for approval by the Laser Safety Subcommittee as the Safe Practice Document for each particular laser system that exceeds the Class 2 hazard level. This document must be approved by the first use date of the designated laser system. When approved, such documents will be housed in the Department of Environmental and Occupational Health and Safety. These documents should include the following information if applicable.

- Laser system classification
- Context and intended use of the laser
- Specific hazards present when the system is in use
- Operating Procedures and safety checklist if necessary
- Safety equipment, interlocks, warning signs, eye wear required for use
- Safety rules regarding student use and the presence of other personnel (note: cleaning staff has keys to all rooms)
- Specific rules regarding visitors
- Name and phone number of the person in charge of the system
- Training required for the operation of the system
- Signed safety affidavits for all operators and a list of these operators
- First aid procedures for the treatment of any injuries
- Accident report procedures
- Related documentation for a medical eye exam preceding the operation of any Class 4 laser system
- Requirement of a medical eye exam upon termination of laboratory duties
- Limit on any long term UV exposure

Appendix B of this manual contains an example of a Safe Practice Document.

As a reminder, these steps are either suggested or mandatory for a system to be considered in safe use by federal standards (ANSI) and OSHA depending on the classification of the laser system. Above all, the Subcommittee would like to help keep the use of lasers on campus a safe procedure.

Appendix A

The Hazards of Handheld Lasers

In order to comply with the Occupational Safety and Health Administration's (OSHA) regulations pertaining to the safe use of lasers, the University has formed a Laser Safety Committee and appointed a Laser Safety Officer (LSO) as required by law. This committee, which functions as a subcommittee of the University's Safety Committee, will oversee all aspects of the use of lasers on campus.

Although not regulated by the standard, the committee is concerned that handheld laser pointers are used by faculty/staff in classrooms and other activities can, under certain conditions, present a hazard. Therefore, this bulletin is being circulated to acquaint the University Community with the safety precautions that should be exercised when using these devices. Please take the time to read this bulletin and if you have any questions, please refer them to EOHS at extension 3700.

What is a Laser?

Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. Energy is amplified to extremely high intensity by an atomic process called stimulated emission. The term radiation is often misinterpreted because the term is also used to describe radioactive materials or ionizing radiation. The use of the word in this context, however, refers to an energy transfer using visible or invisible light.

Laser Beam Hazards

The laser produces an intense, highly directional beam of light. If directed, reflected or focused upon an object, laser light will be partially absorbed raising the temperature of the surface and/or the interior of the object potentially causing an alteration or deformation of the material. These properties which have been applied to laser surgery and materials processing can also cause tissue damage. In addition to these obvious thermal effects upon tissue, there can be photochemical effects when the wavelength of the laser radiation is sufficiently short. Today, most high-power lasers are designed to minimize access to laser radiation during normal operation. Lower power lasers may emit levels of laser light that are not a hazard.

The human body is vulnerable to the output of certain lasers and under certain circumstances exposure can result in damage to the eye and skin. Research relating to injury thresholds of the eye and skin has been carried out in order to understand the biological hazards of laser radiation. It is now widely accepted that the human eye is almost always more vulnerable to injury than human skin. The cornea (the clear, outer front surface of they eye's optics), unlike the skin, does not have an external layer of dead cells to protect it from the environment. The cornea absorbs the laser energy and may be damaged. At certain wavelengths, the lens of the eye may be vulnerable to injury. Of greatest concern however, is the laser exposure in the retinal hazard region of the visible light spectrum. Within the spectral region, concentrated laser rays are brought to focus on a very tiny spot on the retina which may result in retinal injury.

Hazard Alert for Pen and Other Laser Pointers

The use of potentially hazardous visible laser diodes is becoming widespread in many applications. Potential hazards and accidents have been identified by the laser safety community. Users of these products need to be alerted to the potential hazards associated with these devices.

Devices of Concern

One device has raised particular concern: the pen-like laser pointer. Relatively inexpensive, readily available and powered by common batteries, these small lasers produce a very narrow, bright red beam that can be used in presentations or for aiming firearms. One accident occurred when an individual stared into a laser that was mounted incorrectly on a pistol.

Hazard Identification

The potential hazard is limited to the unprotected eyes of individuals who look at the laser from within the direct beam. No skin hazard exists. The natural aversion response or blink reflex of the eye from the bright light would limit exposure to a safe level for devices with a caution label. Devices with a danger label can exceed momentary viewing criteria and an individual should never look at the laser from within the beam. Buyers should be wary of seller claims of device safety.

How Devices are Promoted

These laser pointers are commonly found in novelty mail order magazines, electro-optics trade shows and various electronics stores. Although some of these devices contain warning labels, many have been erroneously advertised as safe.

Conclusion

Pen sized laser pointers are popular presentation tools. They allow speakers to highlight specific portions of their overhead presentation by guiding viewers with a bright red dot of light.

The red dots of light are generated by small battery driven lasers. The most common types of pointers use helium-neon or diode lasers. The helium-neon lasers are Class 2 lasers which means momentary viewing of the direct beam will not cause eye injury. Most diode lasers, which produce light that is a deeper red than that of helium-neon lasers, are Class 3A lasers. Direct viewing of a class 3A laser can potentially cause eye injury. Most Class 3A lasers have danger labels.

Despite their size and the fact that most are powered by small, commonly available batteries, these pointing devices can cause, and have caused, eye damage as a consequence of improper operation. A laser pointer with a caution warning label requires few safety controls and should be purchased rather than one with a danger label.

Laser Pointer Safety Tips

- To prevent injury, laser pointers should never be aimed into the audience. The pointers should be stored with the power sources removed or with the case unscrewed far enough to disable the power source.

- Class 2 helium-neon laser devices are recommended over Class 3A diode lasers due to safety considerations.

- Avoid any type of laser pointer with a danger label.

- When operating any type of laser pointer, always follow the manufacturer's recommendations and avoid directly viewing the laser beam.

Special Note

If you are using a laser pointer that is labeled danger or is unlabeled, it is highly recommended that you replace it with a pointer that is labeled caution. Please call EOHS at extension 3700 if you have any questions or concerns about the use of laser pointers. EOHS will ask the Purchasing Department to order only Class 2A laser pointers for classroom use when possible.

Appendix B

Sample Safe Practice Document

Physics 503L/610L and 502L/611L Laboratories

Safe Use Document

for Class 3 Helium-Neon Lasers

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Some experiments associated with the second and third laboratory courses in the introductory physics sequences require the use of Class 3 helium-neon lasers. The purpose of this document is to outline the accepted safe use of such lasers in the laboratory classroom. The origin of the lasers currently in use in the laboratories is the common supermarket laser scanner unit. It requires an external 10 volt dc power supply which is quite safe for use by students.

However, under no circumstances should students attempt to disassemble the dc power input since the internal supply to the laser is a high voltage tube circuit.

The intended use of the lasers varies by experiment but can be safely operated with some care and use of laser safety goggles which are available in the lab rooms. Specifically, the lasers are used as: optical levers that accentuate small angular differences, light sources for interference and diffraction measurements and lens focal length metering devices. In all cases of use, the instructor should follow the guidelines below.

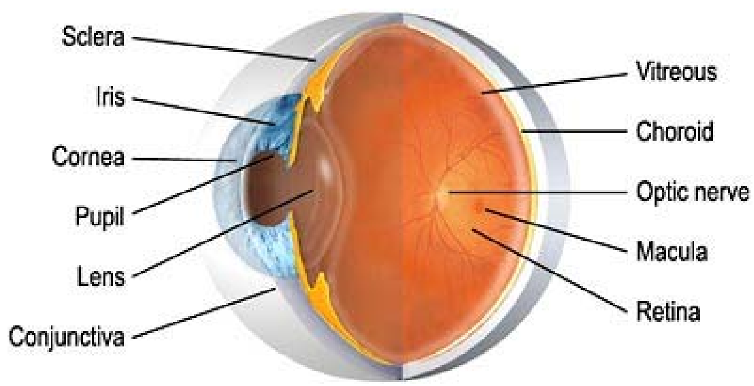
- Instruct students in the safe use of lasers in the lab; require them to read the lab laser safety guidelines to be provided with the syllabus and have them take the laser safety quiz.
- Provide laser safety goggles and demand their use for all students in the laboratory while the lasers are used.
- Connect the dc laser power supplies for students.
- Monitor student laser use during lab for any unsafe practice that may occur despite the student's better judgment.
- Report any laser related injuries to the Chair of the Department of Physics and Astronomy at extension 3616 and to the Office of Environmental and Occupational Health and Safety at extension 3700. An incident/accident report must be filed with EOHS.

Appendix C

Sample Course Handout on Laser Safety

Laser Safety

The lasers used in this course are designed as class 3A devices (see next page). As such, they will have an output power less than 5m Watts. This means the maximum power output is 5 thousandths of one Watt. This may sound like a small amount of power compared to a standard light bulb of 60 Watts. However, the power of a light bulb is radiated in all directions and much of it as heat. This means that your eye looking directly at a 60 Watt bulb is undamaged because only a small amount of the 60 Watts actually enters your eye as visible radiation. It is annoying nevertheless to have the green spot in your field of vision long after staring at a 60 Watt bulb. In addition, the further you are from the bulb, the less light enters your eye. On the other hand, a laser has all its power directed in a narrow beam consisting of a single visible frequency. In the case of the lab lasers, the single frequency corresponds to a visible red color (wavelength = 632nm). This light is nearly as intense at a large distance as it is at small distances.



The fact lasers emit a single visible frequency means the design of the human eye allows all of the light from the laser to enter unhindered. The cornea, lens and humor of the human eye readily accept laser light allowing damage to occur after focus of the incoming light at the retinal surface of the eye. A small depression in the retinal surface about one square millimeter in diameter is called the fovea or fovea centralis. This is where all your precise vision begins. It is the location where light is focused when your eye is adjusted to read or determine details. All color perception also occurs here where the cones of the eye are located. Lasers can be dangerous because the intensity of the beam in the visible spectrum of the laser rivals that of the sun and the lens of the eye focuses this intense light onto the most sensitive and essential part of the eye. In short, staring into a laser pointer is like burning ants with a magnifying glass -- only replace the ants with the retina of your eyeball! This safe use of a laser pointer requires the user keep the light beam from entering anyone’s eye -- including the beam from reflections. Diffuse reflections (like those from a sheet of paper) are safe but specular reflections (from shiny surfaces) can cause damage.

LASER CLASSIFICATION SCHEME

Class 1

These are the lowest power lasers and devices with no recognized danger. For visible red lasers like the helium-neon, the maximum output power is less than 6.5µ Watts. Lasers that fall into his class are laser printers and CD ROM drives.

Class 2

These lasers have enough output power to damage the eye only when the beam enters the eye directly for an extended time. The normal human aversion response time is ¼ of a second. If you turn away from a Class 2 laser within this time, no harm will come to your eye. The effect of Class 2 lasers is similar to that of looking at the sun for a short period of time. The brightness of both will cause the aversion response. Of course, a person can overcome this reflex and stare into the sun (or a Class 2 laser), but this will damage the eye. The maximum output power for this class is lass than 1m Watt. The safe viewing level of diffuse light from a helium-neon laser has an output intensity of less than 2.5m Watts/cm^2 through the aperture of the eye.

Class 3A

A visible laser exceeding 1mWatt output power but less than 5m Watts output power falls within this class. The acceptable viewing level for diffuse light is still 2.5mWatts/cm^2. You must be careful to keep from directing the beam or a reflection of the beam into anyone's eye. Safety goggles are recommended for lasers rated Class 3A.

Class 3B

All lasers output powers above the Class 3A power maximum fall into this class. You must be careful to keep from directing the beam or a reflection of the beam into anyone's eye. Safety goggles are recommended for lasers rated Class 3B.

Class 4

Several hazards exist for these high powered lasers. If you are using one of these, you should have a training course and safety equipment.

Note: If you want to calculate the approximate intensity for the safe viewing of a laser (ex: holography), use the formula:

> Where P is the power output of the laser, and r is the radius of the circular beam. This is only an approximation. To give you an idea, a viewing laser of 1mWatt output power can be sent through a lens to give a nearly circular diverging beam that measures 6cm in radius at some location (about 4 inches across). This formula tells us the intensity entering the eye at this location is 1mWatt/36π=8.8µ Watts/cm^2. This is 280 times smaller than the maximum allowed viewing intensity of 2.5m Watts/cm^2. It would then be safe.

Laser Safety Quiz

Name (print)____

1) Class 3 laser light is dangerous to the human eye because
   a) your eye is designed to allow this color light inside where the light can damage sensitive tissue
   b) the rods of the eye are sensitive to color and the light has this shape
   c) laser light spreads out faster than any other kind of light
   d) the red light of the laser matches the red color of the blood in the eye causing greater absorption damage.

2) Which one of the following statements is true?

   a) A Class 3 laser pointer is a totally harmless toy.
   b) The class 3 laser pointer light is dangerous because it has more power in it than ordinary light bulbs.
   c) Sunlight is much more dangerous to the eye than a class 3 laser pointer.
   d) The output power of a Class 3 laser pointer is small but it is all concentrated in a single direction making it dangerous upon direct entry into the human eye.

3) The part of a human eye that can most likely be damaged by a Class 3 laser is the

   (a) sclera (b) retina (c) lens (d) cornea (e) vitreous humor

4) A student desires to use a laser to view a transmission hologram. The student reads the hazard label on the laser and finds the maximum output power is 6m Watts. How large should the diameter of the circular light pattern diverging from a lens be to insure the student can safely look into the beam?

   ____

5) The most serious damage to a human eye would occur if a Class 3 laser burned the part of the eye called the

   (a) Aqueous humor (b) fovea centralis (c) iris (d) ciliary muscle (e) eyelid

6) Choose from the list below all of the unsafe examples of laser use.

(a) Using a laser pointer for a speech and waving your hands towards the audience with the laser on.
(b) Shining the laser around the room at glossy objects and windows.
(c) Shining a laser pointer toward a chalkboard, away from people, to show the beam in the air with chalk dust.
(d) Using a laser pointer in the dark like a flashlight to view your watch.
(e) Insisting all observers stand around the work area while keeping the laser light from a pointer at waist level for a demonstration.
(f) Playing laser tag with a laser pointer.
(g) Wearing shiny jewelry like watches and bracelets while setting up an experiment with a laser light.
(h) Shining the laser out through lab windows on people passing by on the street or in the hallway.

7. ____________You should never shine a laser into anyone's eye (True or False).

Signature:____

Date:____