Laser Classification and Eye Safety

Lasers sold in the United States are classified in agreement with the Federal Laser Product Performance Standard (FLPPS), which is regulated by the Center for Devices and Radiological Health (CDRH) branch of the Food and Drug Administration (FDA). The classification is a scale from 1 to 4 that is based on the laser’s ability to cause biological damage to the eye and skin.

**Class 1** lasers cannot cause damage to the eye or skin during normal operation. Class 1 lasers output less than 0.4 μW CW (continuous wave). **Class 1A** is a specific designation for Class 1 lasers, which are not intended for viewing, such as supermarket scanners. These lasers are designed so that their emissions do not exceed 0.4 μW CW for 1000 seconds or a maximum power of 4mW.

**Class 2** lasers are low power lasers, though high power than Class 1 lasers. The maximum power that a Class 2 laser can emit is 1 mW. This classification is based upon the fact that human aversion reaction (0.25 s), or blink response, to a bright light will be enough to protect a person from harm.

**Class 3A** lasers emit between 1 and 5 mW CW. They are incapable of damaging the eyes during the aversion response but can cause damage if viewed intrabeam (directly) or if viewed using a microscope or other optical element that focuses the laser beam on to your eye or skin.

**Class 3B** lasers emit between 5 - 500 mW CW. These lasers can cause damage to the eye if viewed directly or from a specularly reflection (a reflection from a mirror-like surface). Class 3B lasers can only cause damage to the eye from a diffuse reflection (reflected in many directions) if viewed through an optical element such as a microscope.

**Class 4** lasers are high powered, emitting greater than 500 mW CW. They are unsafe for viewing under any conditions and can be a potential fire hazard. They will also cause burns on skin and other biological tissue. Class 4 lasers are supposed to be operated in environments where accidental exposure is impossible – i.e., the lasers are operated in an enclosed housing and/or people in the room where the laser is operating wear laser safety glasses and other protective clothing. Interlock systems are used to turn the laser off if the housing is opened or the room door is opened.

**IMPORTANT NOTICE:** The laser diodes used in some of the experiments is a **Class 3** laser. However, the laser driver circuits are designed such that the laser diode will be operated as a **Class 2** laser. **Do not** redesign the laser driver circuits to allow more current through the laser diodes! Eye damage may result if you do not follow the circuit schematics for the laser drivers described in the experimental procedures.

**Laser Safety**

Because the eye is the most sensitive organ to light, laser safety is mainly concerned with eye safety. Because of the focusing action of the eyes, a low power laser of as little as a few milliwatts can cause a burn if focused into the retina (Barat, 15). Injury to the eyes is mainly dependent on the wavelength of the beam, the pulse length of the beam, and the part of the eye affected (Henderson 113).
The cornea is the clear layer of tissue that covers the eye. The lens, together with the cornea, is responsible for forming an image on the retina, which is similar to the manner in which a lens in a digital camera is used to focus an image on a CCD. The retina is responsible for converting light and movement into electrical signals, which are sent to the brain in the form of impulses though the optic nerve. The parts of the eye described are shown in Fig. 1.

Photokeratitis, or welders flash, is a temporary condition caused by damage to the cornea from ultraviolet-B and ultraviolet-C (UV) radiation (100 to 315 nm). UV-A (315 to 400 nm) radiation can cause damage to the lens, resulting in the formation of cataracts. Visible light and IR-A (400 to 1400 nm) can cause damage to the retina, the most vulnerable part of the eye, because of the lens’ focusing effects. IR-B and IR-C (1400 to $1 \times 10^6$ nm) can cause thermal damage to the cornea.

Although the retina does not have pain receptors, it is protected by various aversion responses such as blinking, squinting, constriction of the pupils, and moving the head away. Aversion responses, however, may not be enough to protect the eye from higher power beams. In the unfortunate case that retinal damage does occur, it can result in partial or total blindness. To make matter worse, aversion responses work only for visible light, leaving the cornea and lens vulnerable to damage (Henderson p. 121).

**Symptoms of Laser Burn** (Barat p.18)

A minor burn to the cornea usually causes a feeling of having sand in the eye. Other symptoms include headaches shortly after exposure, excessive watering of the eyes, and the appearance of floaters. Floaters are random distortions in vision which usually occur after a blink or after the eyes have been closed for a few seconds. Minor laser injuries can possibly be mistaken for floaters.

A bright flash from a visible light laser beam produces and after image of the laser’s complimentary color. For example a bright green flash should produce a red after image (Barat19). When the retina is damaged this ability to determine blue and green after images may be affected. Damage to the retina may also cause pigmentation.

**Preventing Eye Injury**

Even though several of the experiments require the use of a Class 2 laser, it is good practice to never look directly at the beam of a laser for a prolonged period of time or shine a laser beam at anyone, regardless of its classification. Never view a laser beam through microscope or other device that will focus the laser beam. Also, avoid aiming a laser beam at a reflective surface. The laser should never be operated as a Class 3 laser.
In Case of a Suspected Eye Injury as described in Laser Safety Management by Ken Barat

1. Determine if any local assistance is available, such as a coworker.
   a. If yes, this person follows steps 2 and 3.
   b. If no, call for assistance. Do not go by yourself.
2. Keep the person as calm as possible.
3. Call the medical or fire department.
   a. Regular hours: you can transport the person to medical.
   b. Off hours: fire department to provide transportation.
4. Notify the individual’s or the area supervisor.
5. Notify the Laser Safety Officer (Instructor in the case of this lab).
6. Work needs to stop until an evaluation is conducted to see if a systematic error exists.

References