Laser Safety Basics

Laser Classes
The Center for Devices and Radiological Health (CDRH) (formerly the Bureau of Radiological Health, BRH), a division of the U.S. Food and Drug Administration, has mandated that commercially available lasers be manufactured according to certain standards. The State of Michigan follows CDRH protocols in its schools and other institutions. The CDRH assigns each laser to a class based upon the ability of that laser to cause damage to human tissue. While some lasers may pose a threat due to high voltage electric shock, release of poisonous gases, low temperature burns due to cryogenic equipment, explosions resulting from strongly reacting gas or fluid mixtures, and other hazards, the main source of danger is direct exposure of the eye to the intense light of a laser beam. This is the main hazard we will concern ourselves with in this course.

Class I lasers are incapable of causing damage when the beam is directed at the eye under normal operating conditions. These are exempt from any controls. These include helium-neon lasers operating at less than a few microwatts of radiant power.

Class IIa lasers can produce retinal injury when stared at for a long time (over 1000 seconds) but do not have sufficient power to cause accidental injury. A bar-code scanner is a typical class IIa device.

Class II devices can cause harm if viewed directly for 1/4 s or longer. This includes He-Ne lasers with output up to 1 mW.

Class IIIa (This is the old BRH class IIIb) lasers have outputs less than 5 mW. These lasers can cause injury when the eye is exposed to either the beam or its reflections from mirrors or other shiny surfaces (called specular reflection). Diffuse reflections from rough surfaces will not normally cause injury unless the reflected beam is further focused onto the eye. Most of the helium-neon lasers found in routine educational and shop use are class IIIa. The power of these lasers is sufficiently low that the eye will normally be protected from permanent damage in case of accidental exposure by natural pupil contraction, blink, and aversion reflexes. Commercially available laser pointers are class IIIa or less.

Class IIIb lasers have output power of 5 to 500mW. The argon lasers typically used in laser light shows are of this class. Higher power diode lasers (above 5 mW) from optical drives and high performance laser printers also fall int this class.

Class IV lasers have outputs exceeding 500 mW. These devices produce a beam that is hazardous directly or from specular or diffuse reflection and can produce a skin burn. Many ruby, carbon dioxide, and neodymium-glass lasers are class IV.

The CDRH requires safety precautions to be met for the public use of each class of laser
Radiation Damage to the Eye

The human eye consists of an opaque membrane called the sclera that acts like a sack to hold a transparent gelatin-like fluid called the vitreous humor. The front of the sclera is a hard but transparent region called the cornea. Behind the cornea sits a thin watery fluid, the aqueous humor. Between the vitreous and aqueous humor is the crystalline lens. The aperture of this lens, called the pupil, is controlled by the nearly opaque, pigmented iris. The lens shape can be changed by the ciliary muscles, attached to the sclera. The normal eye focuses light onto optical receptors called rods and cones located in the retina at the rear of the eye. The retina lies on the choroid, a region containing most of the eye’s blood vessels, and the most sensitive part of the retina is a region dense in receptors called the fovea. Signals from these receptors enter the brain through the optic nerve. It is interesting to note that more of the brain’s volume is devoted to the processing of visual signals than is used for all the other senses combined.

Laser light can damage the eye in several ways. Laser light in the visible to near infrared (i.e., 400 - 1400 nm) can cause damage to the retina resulting in scotoma (blind spot in the fovea). This wavelength band is known to radiation health physicists as the "retinal hazard region". Laser radiation at wavelengths outside the retinal hazard region can cause damage to the cornea and lens.

The typical result of exposure to a hazardous laser beam at optical wavelengths (400 - 750nm) is the sensation of a bright colored flash and an after-image of the complementary color. A red laser beam, for example, would produce a flash of red light followed by a blue-green after-image. Eye damage due to laser light is usually localized in a small area of the eye and may not be easy to detect. A problem for those working with lasers is that each exposure can destroy a tiny patch of retinal receptors and although any one such exposure produces only a small amount of damage, the cumulative effect of many exposures is a significant loss of vision.

Laser pointers have come in for sharp criticism recently and many schools prohibit their use. This is probably an overreaction. The beam would have to be directed onto the pupil of the eye from close by for a period of a few seconds or more to produce significant injury and normal blink and avoidance reactions will prevent this. While reports of injuries due to laser pointers are often exaggerated, there are other hazards associated with these devices: in particular, police officers are trained to regard an uninvited laser spot as a targeting aid on a weapon and to take immediate and forceful countermeasures.

Some Guidelines for Laser Safety:

1. **Never look into the beam of any laser.**
2. **Be aware of the hazards posed by your laser.** For example, a class II laser will not cause injury unless one stares into the beam. The beam from a class IIIa laser (or its specular reflection) can cause permanent injury if it is directed onto an eye for even a very brief period, while its
diffuse reflections will not normally cause injury. Even the diffuse reflections from a class IILb laser can be hazardous.

3. **Reduce the beam intensity whenever possible.** Many applications do not require the full power of the available laser. The beam’s intensity can be reduced by using ordinary absorbing filters or polarizer pairs and it may also be reduced by causing the beam to pass through a diverging lens which acts as a beam-spreader.

4. **Aim the laser well away from others.** In this classroom that means aiming the beam toward the wall adjacent to you lab station. Never adjust the beam without informing your lab partner(s). The beam should not be moved more than about ten degrees away from a position where it points directly toward the wall.

5. **Use an appropriate target.** A good beam-stop is any surface that absorbs most of the light falling on it and gives only diffuse but not specular reflections. Dull black surfaces are best.

6. **Do not allow the beam to inadvertently reflect from metal or glass surfaces.** Remove wrist watches, rings, bracelets, and any other object that may accidentally come into contact with the beam. Remove from the active work area test tubes, microscope slides, metal supports, and any other routine lab equipment that might reflect the beam.

7. **Use protective eyewear.** Protective goggles or spectacles should be worn for all routine use of class III and class IV lasers. Look away from the laser and any bright surface when removing protective eyewear if lasers are still operating. Remember that eyewear is wavelength specific: a pair of goggles than effectively blocks red laser light affords no protection for green laser light.

In this class there will generally be two experimenters at each station. Both individuals are responsible for ensuring proper beam termination and for making certain that their laser beam cannot accidentally strike the eye of anyone else in the class, including anyone who happens to be passing their station.