LASER SAFETY PROGRAM

Safety & Security Services

August, 2003

1.0 Glossary of Terms

Absorption – Transformation of radiant energy to a different form of energy by interaction with matter.

Attenuation – The decrease in the radiant flux as it passes through an absorbing or scattering medium.

Aversion response – Movement of the eyelid or the head to avoid an exposure to a noxious stimulant or bright light. It can occur within 0.25 seconds, including the blink of reflex time.

Beam – A collection of rays, which may be parallel, divergent or convergent.

Beam diameter – The distance between diametrically opposed points in that cross-section of a beam where the power per unit area is 1/e (0.368) times that of the peak power per unit.

Coherent – A light beam is said to be coherent when the electric vector at any point in it is related to that at any other point by a definite, continuous function.

Continuous Wave (CW) – The output of a laser, which is operated in a continuous rather than a pulsed mode.

Controlled Area – An area where the occupancy and activity of those within is subject to control and supervision for the purpose of protection from radiation hazards.

Cornea – The transparent outer coat of the human eye, which covers the iris and crystalline lens. The cornea is the main refracting element of the eye.

Diffuse Reflection - Change of the spatial distribution of a beam of radiation when it is reflected in many directions by a surface or by a medium.

Divergence – The increase in the diameter of the laser beam with distance from the exit aperture. The value gives the full angle at the point where the laser energy or irradiance is 1/e (36.8%) of the maximum value.

Diffraction – Deviation of part of the beam determined by the wave nature of radiation and occurring when the radiation passes the edge of an opaque obstacle.

Electromagnetic Radiation – The flow of energy consisting of orthogonally vibrating electric and magnetic fields lying transverse to the direction of propagation.

Embedded Laser – A laser that is contained within a protective housing of itself or of the laser system in which it is incorporated.

Hertz (Hz) – The unit, which expresses the frequency of a periodic oscillation in cycles per second.

Irradiance (E) At A Point Of A Surface – Quotient of the radiant flux incident on an element of surface containing the point at which irradiance is measured, by the area of that element. Units are watt per square centimeter (W-cm2).

Joule – A unit of energy. 1 joule = 1 watt/second.

Laser – A device, which produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to lower energy levels. An acronym for Light Amplification Stimulated by Emission of Radiation.

Limiting Aperture – The maximum diameter of a circle over which irradiance and radiant exposure can be averaged.

Maximum Permissible Exposure (MPE) – The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin.

Nominal Hazard Zone (NHZ) – The space within which the level of direct, reflected, or scattered radiation during normal operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the appropriate MPE level.

Protective Housing – An enclosure that surrounds the laser or laser system that prevents access to laser radiation above the applicable MPE level. The aperture through which the useful beam is emitted is not part of the protective housing. The protective housing may enclose associated optics and a work station and shall limit access to other associated radiant energy emissions and to electrical hazards associated with components and terminals.

Pulse Duration – The duration of a laser pulse, usually measured as the time interval between the half-power points on the leading and trailing edges of the pulse.

Pupil – The variable aperture in the iris through which light travels to the interior of the eye.

Q-Switch - A device producing very short (<30ns) high power pulses.

Radiance (L) – Radiant flux or power output per unit solid angle per unit area.

Radiant Energy (Q) – Energy emitted, transferred or received in the form of radiation (Joule).

Radiant Exposure (H) – Surface density of the radiant energy received. (Joules / cm2).

Radiant Flux (W) – Power emitted, transferred or received in the form of radiation (Watt).

Shall – The word “shall” is to be understood as mandatory.

Should – The word “should” is to be understood as advisory.

Specular Reflection – A mirror like reflection.

2.0 PREAMBLE

The purpose of Algonquin College's Laser Safety Program is to provide detailed description on the safe use of lasers and laser systems at the College.

3.0 PURPOSE & SCOPE

The use of lasers in the workplace presents a variety of chemical and physical hazards, to varying degrees, dependant on the class of laser and the specific application. The purpose of this document is to facilitate appropriate assessment of these hazards and identify the corresponding engineering, administrative and personal protective equipment controls that must be in place to mitigate the risk to staff and students. It describes the roles and responsibilities of personnel/students who work with or supervise laser operations and identifies the training required for all College operations involving laser use. Unless specifically stated otherwise in this document, work standards for the safe operation of lasers and laser systems at Algonquin College shall follow the recommendations of ANSI Z136.1-2000, "American National Standard for the safe use of Lasers" and ANSI Z136.5-2000, "American National Standard for the safe use of Lasers in Educational Institutions. The Laser Safety Program applies to all persons: employees, students and visitors operating or working in proximity to lasers and considers these persons "laser workers" for the purpose of the program. All laser workers must be trained in accordance with the program and / or familiar with all applicable elements.

4.0 LASER SAFETY STANDARDS AND LEGISLATION

Any requirements, guidelines and reference standards (including ANSI Z136.1-2000 – Safe use of Lasers and ANSI Z136.5-2000 – Safe use of Lasers in Educational Institutions) established or adopted by the Ontario Ministry of Labour for the safe use of lasers will be followed in this program.

5.0 ROLES AND RESPONSIBILITIES

5.1 Laser Safety Officer

In areas where lasers are used, there should be one person designated by the employer as the person responsible for laser safety if Class 3b and 4 lasers are in use. The laser safety officer's responsibilities include:

1. The LSO will inspect all teaching equipment and research experimental set-ups involving the use of Class 3b and 4 lasers, in either teaching or research environments, and has the authority to discontinue, cancel, or postpone a demonstration or experiment until a safety issue is rectified.

2. Ensuring that an effective laser safety program is developed and instituted whenever there is a special hazard due to laser radiation.
3. Ensuring workers/students are properly trained according to the laser safety program.
4. The LSO will recommend or approve protective equipment, eyewear, clothing, barriers, screens, etc, as may be required to assure the safety of each person who may work within the NHZ.
5. The LSO will be responsible for the appropriate wording and labels on all laser systems and for any commercially manufactured laser devices that have been modified in any way that affects their hazard classification. The LSO will also be responsible for assuring that these prescribed controls are in effect, and that faculty, staff, and students observe these controls.
6. Conducting hazard assessments and setting up standard operating procedures for all new and existing laser equipment.
7. Maintaining an inventory of all Class 3b and 4 lasers.
8. Providing consultative services on evaluation and control of laser hazards;
9. Annually reviewing the laser safety program and SOP's and consulting Safety and Security Services of updates and/or changes that need to be made due to new equipment or changes to existing equipment.
10. To report to the Occupational Health & Safety (OHS) section lasers or laser systems without adequate hazard controls;
11. To maintain records as required by regulatory agencies in laser safety.

5.2 Supervisor Duties

Supervisors will be knowledgeable of education and training requirements for laser safety, the potential laser hazards and associated control measures for all lasers under the supervisor's authority. The supervisor will be familiar with general operating procedures of lasers under their control.

1. Ensure that laser workers/students have been trained in the safe operation of the lasers or laser systems.
2. Ensure that laser workers/students prior to operating or working in proximity to Class 3b or Class 4 lasers participate in the Laser Safety Program Training.
3. Report known or suspected accidents to the Laser Safety Officer.
4. Ensure that lasers under their control are not operated or modified without approval by the Laser Safety Officer.
5. Ensure that all administrative and engineering controls are followed.
6. Ensure that Standard Operating Procedures (SOP's) are written and available to Laser Workers under their supervision.

5.3 Laser Workers/Students Duties

1. Will participate in the Laser Safety Training Course.

2. Will comply with regulations and standards prescribed by Safety and Security Services, Laser Safety Officer and the lab supervisor.
3. Will become familiar with standard operation procedures (SOP's) and specific safety hazards of lasers which they are operating or working in proximity to.
4. Will not operate a Class 3b or Class 4 laser unless authorized by the laser supervisor.
5. Will report known or suspected accidents to their laser supervisor and the Laser Safety Officer immediately.
6. Will wear all personal protective equipment prescribed by Safety and Security Services, Laser Safety Officer and the lab supervisor.
7. Will undergo reasonable prescribed medical surveillance.

6.0 LASER BASICS

The acronym **LASER** stands for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation.

The energy generated by the laser is in or near the optical portion of the electromagnetic spectrum (see Figure 1). 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. Energy moves from one location to another by conduction, convection, and radiation. The color of laser light is normally expressed in terms of the laser's wavelength. The most common unit used in expressing a laser's wavelength is a nanometer (nm). There are one billion nanometers in one meter.

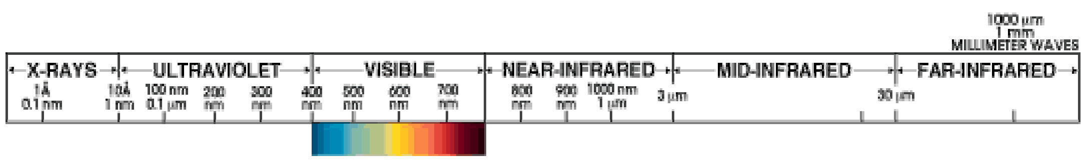


Figure1.
The optical spectrum. Laser light is non-ionizing and ranges from the ultra-violet (100 - 400nm), visible (400 - 700nm), and infrared (700nm - 1mm).

6.1 Laser Components

All lasers contain three primary sections (Figure2) :

1. **Active Medium**

The active medium contains atoms, molecules or ions whose electrons may be excited to a metastable energy level by an energy source to produce laser light. The active medium can be either solid crystalline materials such as ruby, or solutions of organic dyes, or gases such as Helium/Neon, or semiconductors such as Gallium/Aluminium/Arsenic. The material determines many of the laser beam's output characteristics, including its wavelength.

The type of lasing material used allocate lasers. The four types are: Solid State, Gas, Dye and Semiconductor.

- Solid State Lasers
  e.g. ruby laser, Neodymium YAG laser (ND: YAG). The term YAG is an abbreviation for the crystal – Yttrium Aluminium Garnet that serves as the host for the Neodymium ions.
- Gas Lasers
  e.g. Carbon Dioxide, mixture of Helium and Neon, Nitrogen
- Dye Lasers
  e.g. Use a laser medium that is usually a complex organic dye in liquid solution or suspension. (Rhodamine 6G).
- Semiconductor or Diode Lasers
  e.g. Galium Arsenide Diode Laser

2. **Excitation Mechanism**

The input energy device, which pumps energy into the active medium, determines the excitation mechanism. This mechanism can be optical, electrical or chemical.

3. **Optical Resonator**

The optical resonator consists of two specially designed mirrors. The high reflectance mirror reflects essentially 100% of the light hitting it while the other partially transmissive mirror (called the output coupler) reflects less than 100% of the light hitting it and transmits the remainder.

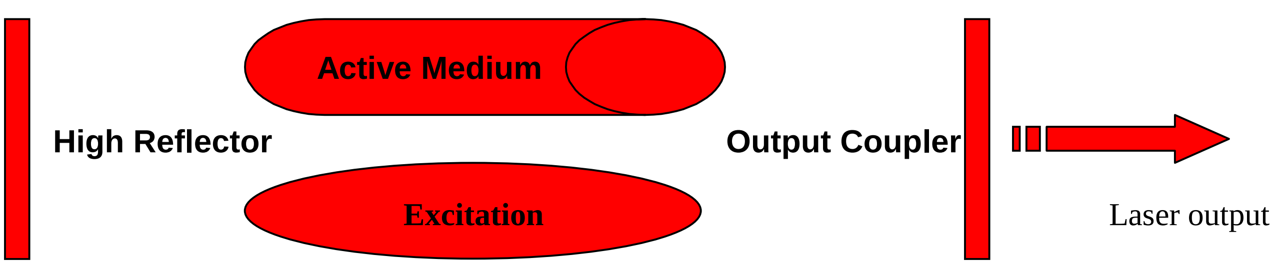
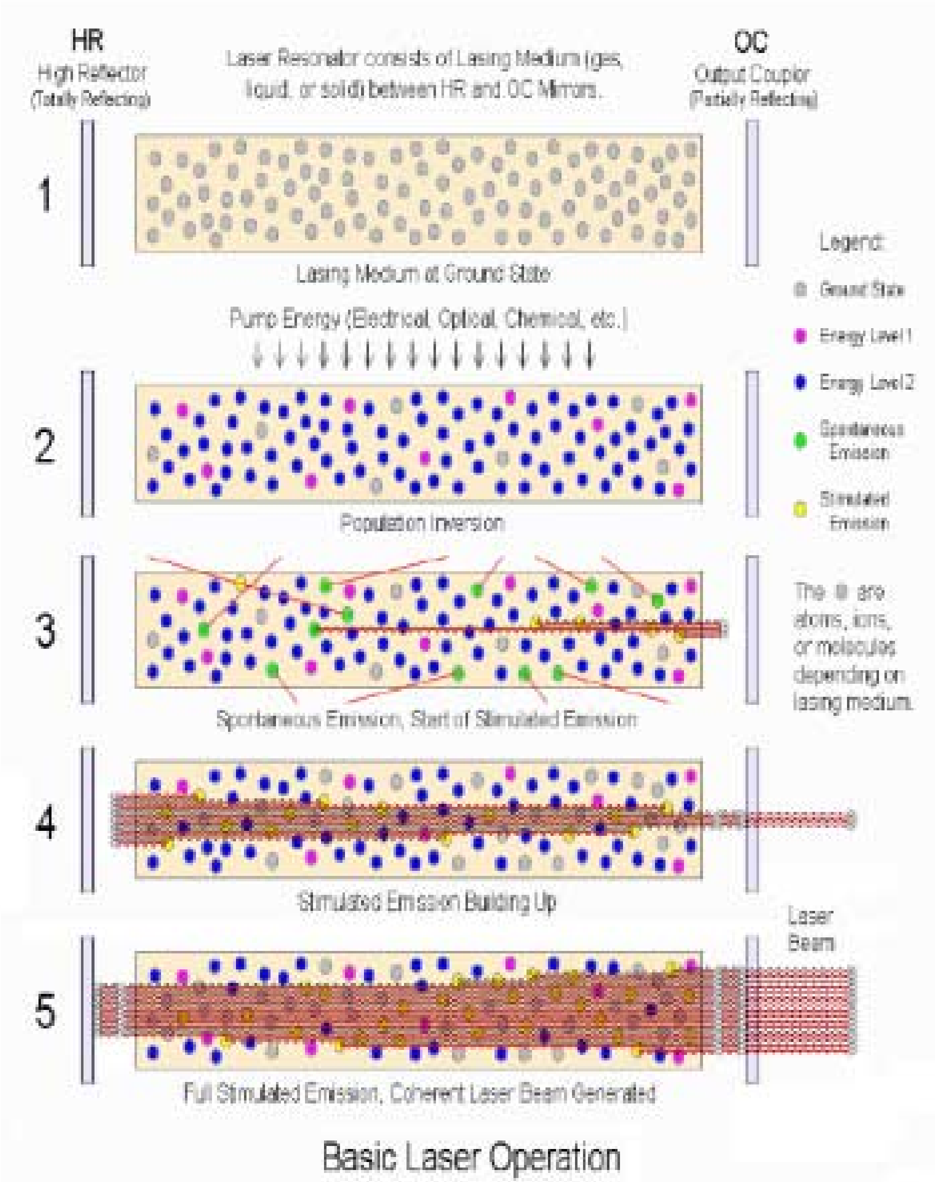


Figure. 2 - Laser Components

6.2 Laser Characteristics

Laser light is monochromatic, directional and coherent. Monochromatic means that all the light produced by the laser is of one wavelength. Directional means that the beam from the laser does not diverge as quickly as other light. Coherent means that all the waves of light are generated in phase with each other.



7.0 CLASSIFICATION OF LASERS

All lasers are classified by the manufacturer and labelled with the appropriate warning labels. An unclassified laser or a modified laser not properly classified must be classified prior to use. The following criteria are used to classify lasers:

1. Wavelength or wavelength range.

2. For continuous wave (CW) or repetitively pulsed lasers the average power output (Watts) and limiting exposure time inherent in the design are considered.

3. For pulsed lasers: total energy (Joule) per pulse or (peak power), pulse duration, pulse repetition frequency, and the emergent beam radiant exposure (J/cm^2).

4. For extended source lasers or laser systems (e.g. laser arrays, laser diodes, and lasers having a permanent diffuser within the output optics): in addition to the parameters listed above, the maximum angle subtended must be known, and the source radiance or integrated radiance may be needed.

Below is a brief summary of laser classification. For detailed classification, refer to ANSI Z136.1-2000 – Safe use of Lasers and ANSI Z136.5-2000 – Safe use of Lasers in Educational Institutions

7.1 Class 1 Lasers (Exempt)

The number of Class 1 lasers at the College is increasing because IR lasers and laser diodes (i.e., lasers emitting wavelengths above 1400 nm) are becoming more common. General-purpose Class 1 lasers are not hazardous. They are incapable of producing harmful accessible radiation or causing a fire. Therefore, Class 1 lasers are generally exempted from most control measures or other forms of surveillance. Lasers that are not hazardous for continuous viewing or are designed in such a way that human access to laser radiation is prevented. They are low power lasers or high power embedded lasers (e.g. laser printers, CD ROM devices).

7.2 Class 2 Lasers (Low Power)

A Class 2 laser emits visible but low-power radiation in either continuous wave (CW) or pulsed visible wavelengths of 400 to 700 nm. CW Class 2 lasers are limited to powers of less than 1 mW.

Natural human aversion time of 0.25-s to bright light provides the necessary eye protection for Class 2-laser users; however, directly viewing the beam of a Class 2 laser for periods exceeding the 0.25-s aversion time may be hazardous. Class 2 lasers do not present a fire hazard.

Typically, scanning systems, such as bar-code scanners, use Class 2 lasers. Although the beams from these lasers are not intended for viewing, they are not hazardous even if an individual views the beam for up to 1000 s.

7.3 Class 3a Lasers (Medium-Power)

Class 3 lasers are divided into two subclasses (3a and 3b). Class 3a lasers can emit visible or invisible radiation. Normally, their beams are not hazardous when viewed momentarily with the naked eye; but when optical instruments (such as microscopes or binoculars) are used to view the beams, the beams can be hazardous to the eyes. Diffuse reflections of Class 3a lasers are usually not hazardous. A Class 3a laser is not a fire hazard.

Visible Class 3a lasers have accessible output powers up to five times the emission limits of Class 2 lasers. Invisible Class 3a lasers have accessible output powers up to five times the emission limits of Class 1 lasers. Actual values depend on the laser's wavelength, pulse duration, exposure duration, and number of pulses during the exposure duration. Engineered and administrative controls are not applicable to public-use lasers (e.g., those in laser pointers and bar code scanners).

7.4 Class 3b Lasers (Medium-Power)

Class 3b lasers have average powers up to 500 mW for CW or repetitive-pulsed lasers. Single-pulse emission levels range from 30 mJ to 150 mJ, depending on the wavelength. Class 3b lasers are hazardous to unprotected eyes and may be hazardous to the skin. Diffuse reflections from Class 3b lasers may also be hazardous, such as when an individual stares at the diffusing surface from within the nominal hazard zone (NHZ).

7.5 Class 4 Lasers (High Power)

The average power of a CW or repetitively pulsed Class 4 laser can exceed 500 mW. Single-pulse emission levels exceed 30 mJ to 150 mJ, depending on the wavelength. Beams can be either visible or invisible. Class 4 lasers are powerful enough to produce diffuse reflections that could rapidly injure the eyes or skin. Consequently, Class 4 lasers are hazardous to the eyes and skin, whether exposure is to the direct beam of the laser, its specular reflection, or diffuse reflections.

Some Class 4 lasers are capable of igniting combustible materials. As a rule of thumb, lasers emitting more than 2 W/cm^2 are considered ignition hazards.

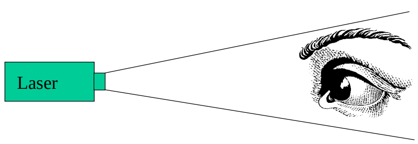
8.0 HAZARD EVALUATION

A hazard evaluation of the laser being used is required for the purpose of classifying the laser and to determine the types of precautionary measures required. The following are some terms and conditions that should be determined for Class 3b and 4 lasers for the purpose of hazard evaluation (see ANSI A-136.1-2000 for details):

Viewing Conditions: intrabeam or from specular reflections versus **diffuse reflection**

Intrabeam Viewing refers to viewing the direct beam or beam reflected off smooth surface. **Specular reflection** is mirror-like reflections and can reflect close to 100% of the incident light.

- Intrabeam Viewing – Direct

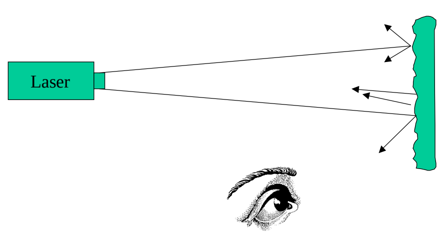


Intrabeam viewing of direct (primary) beam.
This type of viewing is most hazardous.

- Intrabeam Viewing – Specular

Intrabeam viewing of a specularly reflected (secondary) beam from a flat surface reflector. Specular reflections are most hazardous when the reflecting surface is flat.

- Diffuse Reflection



Extended source viewing of a normally diffuse reflection. Diffuse reflections are not normally hazardous, except with very high power Class 4 lasers.

Diffuse Reflections (extended source) result when surface irregularities scatter light in all directions. Extended source viewing produces a larger retinal image.

8.1 Maximum Permissible Exposure (MPE) (J/cm^2 or W/cm^2)

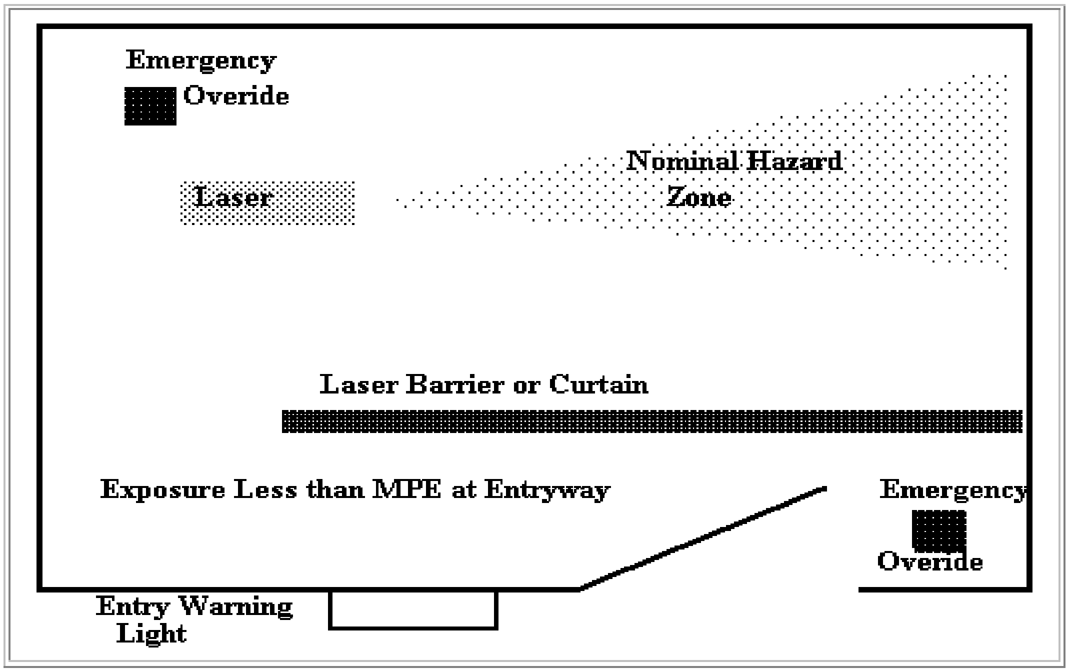
The MPE is defined in ANSI Z-136.1-2000 as "The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin." The MPE is not a distinct line between safe and hazardous exposures. Instead they are general maximum levels, to which various experts agree should be occupationally safe for repeated exposures. The biological **effects of laser radiation** are dependent on the wavelength of the laser and exposure duration. Therefore MPE's are calculated using correction factors for these indices. Calculations of MPE's are done by the Laser Safety Officer using ANSI Z-136.1-2000 for each Class 3b and Class 4 laser.

8.2 Nominal Hazard Zone (NHZ)

In some applications open beams are required, making it necessary to define an area of potentially hazardous laser radiation. This area is called the nominal hazard zone (NHZ) which is defined as a space within which the level of direct, scattered or reflected laser radiation exceeds the MPE. The purpose of a NHZ is to define an area in which control measures are required. The Laser Safety Officer will determine the NHZ and the control measures to protect the laser worker from exposure to radiation above the MPE.

Page 16 (Figure 3) is an example of entryway controls for a Class 4 laser without entryway interlocks if a non-defeatable interlock was placed on the entryway the Laser barrier and entry warning light may be omitted.

Figure 3 - Nominal Hazard Zone and Entryway Controls



*Picture from Waterloo University

9.0 LASER HAZARDS

There are two types of laser hazards: the laser beam hazards and the non-beam hazards. Laser beam hazards include eye and skin burns which are due to laser beam shining on a person's body. Non-beam hazards are associated with the laser equipment or the hazardous substances released from the laser equipment, and fumes emitted from materials exposed to laser beams, including laser-plumes produced during surgical procedures.

Sources of laser hazards include:

- Accidental eye exposure during alignment
- Misaligned laser beam
- Lack of eye protection
- Equipment malfunction
- Improper handling of high voltage systems
- Use of unfamiliar equipment
- Improper restoration of equipment following service

Exposure to laser radiation can produce eye and skin damage. The extent of the damage depends on the wavelength and intensity of the radiation, and on the duration of exposure.

9.1 BEAM RELATED HAZARDS

Improperly used laser devices are potentially dangerous, and effects can range from mild skin burns to irreversible injury to skin and the eye. The biological damage caused by lasers is produced through thermal and photochemical processes. The thermal process results from denaturation of tissue proteins due to temperature rise following absorption of laser energy.

Thermal damage is generally associated with lasers operating at exposure times greater than 10 microseconds and in the wavelength region from the near ultraviolet to the far infrared (0.315-103 µm). The thermal reaction in tissues to absorbed radiant energy is strongly dependent upon both duration and area of the exposure. Laser-induced skin lesions are not different from any localized thermal wound and should receive similar medical treatment.

9.1.1 Effects on the Eyes

Exposure of the eyes to laser radiation above the MPE is hazardous and must be avoided. The potential for injury to the different structures of the eye (Fig. 4) depends upon which structure absorbs the energy. Laser radiation may damage the cornea, lens or retina depending on the wavelength, intensity of the radiation and the absorption characteristics of different eye tissues.

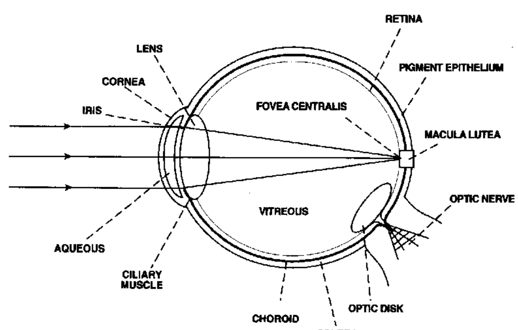


Fig. 4 - Structures of the Eye

Below are the effects of optical radiation at various wavelengths on various structures of the eye (refer to Fig. 5.):

Wavelength: **Visible and near-infrared wavelengths, 400 to 1400 nm**
Radiation is transmitted through the ocular media with little loss of intensity and is focused on the retina. Laser radiation in this range is termed the *retinal hazard region*. The focusing effects of the cornea and lens will increase the irradiance on the retina by up to 100,000 times.

Wavelength: **Middle, far-infrared (1400nm-1mm) and Middle Ultraviolet (180nm-315nm)**

The surface of the cornea absorbs radiation at these wavelengths. The absorption of middle ultraviolet radiation by the cornea produces photokeratitis (welders flash) by a photochemical process. For middle and far-infrared radiation, damage to the cornea results from the absorption of energy by tears and tissue water causing a temperature rise. Middle- infrared radiation penetrates deeper and may lead to the development of cataracts.

Wavelength: **Near-ultraviolet (315nm-400nm, UV-A)**

Radiation at the near-ultraviolet is absorbed in the lens and may contribute to certain forms of cataracts.

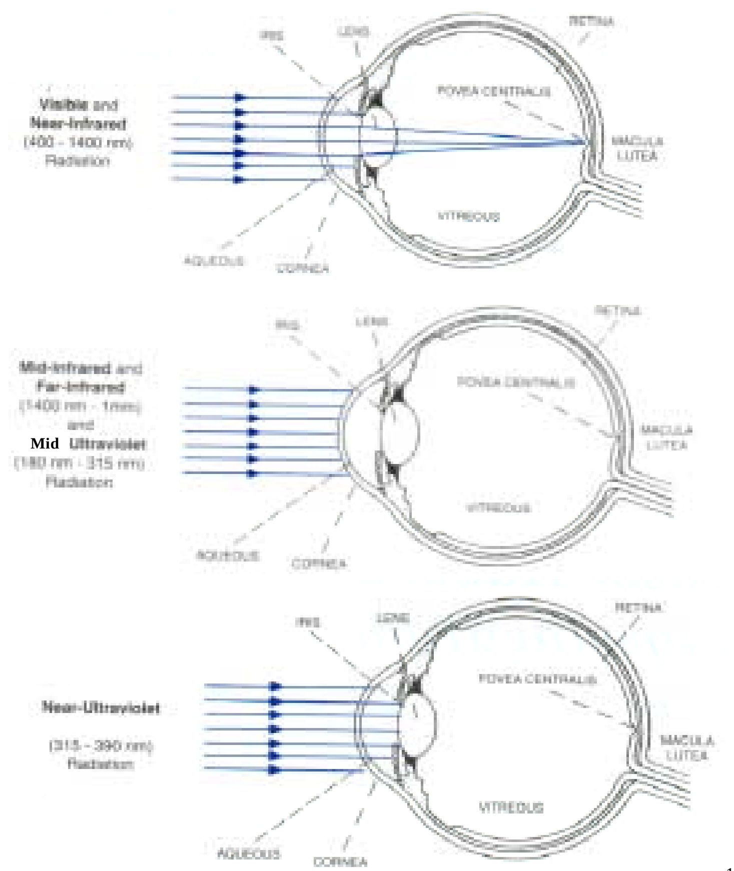
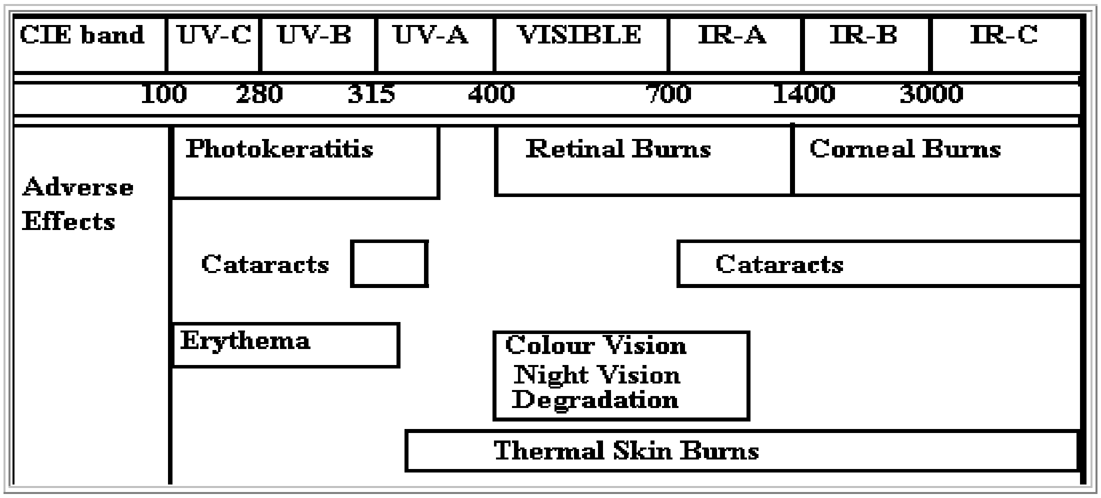


Fig.5 - Absorption of various wavelengths of light by the human eye.

Summary of Wavelengths of Light and their Effects on Tissues

Below is a summary of interaction of optical radiation and various tissues. The wavelengths are divided into bands as defied by the International Commission on Illumination (CIE).



* Figure 6.

9.1.2 Effects on the Skin

The effects of laser radiation on the skin range from mild burns due to acute exposure to high levels of optical radiation, to aging, to potential carcinogenesis due to exposure to specific ultraviolet wavelengths. The large surface area of the skin makes it readily accessible to both acute and chronic exposures to various forms of optical radiation, which can produce varying degrees of skin damage. Some individuals are photosensitive, or may be taking prescription medication that induces photosensitivity. Particular attention must be given to the effect of these (Prescribed) drugs such as some antibiotics and fungicides in relation to the individuals taking these drugs.

Skin effects are usually considered of secondary importance, however, with the more widespread use of lasers emitting in the ultraviolet spectral region as well as higher power lasers, skin effects have assumed greater importance.

Erythema (sunburn), skin cancer and accelerated skin aging are possible in the 230 to 380 nm wavelength range. The most severe effects occur in the UV-B (280 - 315 nm). Increased pigmentation can result from chronic exposures in the 280 to 400 nm range. In addition, photosensitive reactions are possible in the 310- 600 nm wavelength regions. The bioeffects in the infrared (700 - 1000nm) will be skin burns and excessive dry skin.

9.2 NON-BEAM RELATED HAZARDS

9.2.1 Electrical Hazards

Both pulsed and CW lasers may have high voltage and high current power supplies, and pulsed lasers utilize capacitor banks. Some gas lasers have radio-frequency power supply circuits.

Improper grounding or shielding, or failure to follow standard electrical safety procedures during maintenance and service may result in electrical shock, burns or blistering, or electrocution. For example, since static electricity can be built up when some solvents flow through plastic tubing, grounding wire should be installed inside the tubing.

9.2.2 Chemical Hazards

Many dyes used as lasing medium are toxic, carcinogenic, mutagenic or corrosive. Exposure to dyes during solution preparation should be minimized. Safety information regarding the dye can be obtained by reading the appropriate Material Safety Data Sheet.

Special Optical materials used for far infrared windows and lenses have been the source of potentially hazardous levels of airborne contaminants. For example, calcium telluride and zinc telluride will burn in the presence of oxygen when beam irradiance limits are exceeded. Exposure to cadmium oxide, tellurium, and tellurium hexafluoride should also be controlled.

Solvents used for mixing the dye may be flammable and/or toxic (irritants, narcotics, or anaesthetics). A low dye concentration may mean solvents are of the greater concern.

Cryogenic fluids, such as liquid nitrogen, helium and hydrogen, are used in cooling systems of certain lasers. Skin and eye contact with such materials could cause frostbite.

Compressed gases used in some lasers can be hazardous. For example, chlorine gas is corrosive; helium and argon are asphyxiant (displaces oxygen); and hydrogen is a flammable gas. There is also the hazard of unsecured cylinders: if a cylinder should have its valve broken off in a fall, it becomes an uncontrolled missile.

9.2.3 Fire Hazards

Class 4 lasers represent a fire hazard. Depending on construction material beam enclosures, barriers, stops and wiring are all potentially flammable if exposed to high beam irradiance for more than a few seconds.

Flammable solvents, if used in an enclosed area without adequate dilution or exhaust ventilation, pose a fire or explosion hazard in the presence of an ignition source.

9.2.4 Explosion Hazards

Explosion hazards may exist if high pressure arc lamps, filament lamps or capacitor banks fail during operation. These components should be enclosed in a housing which will withstand the maximum explosive force that may be produced. Laser targets and some optical components may also shatter if heat cannot be dissipated quickly enough. Consequently, care must be used to provide adequate mechanical shielding when exposing brittle materials to high intensity lasers.

9.2.5 Collateral Radiation

*Radiation other than laser radiation associated with the operation of a laser system, such as radio frequency (RF) radiation associated with some plasma tubes and x-ray emission associated with high voltage power supplies are potentially very dangerous and shall be kept below the necessary protection guides.

10.0 REGISTRATION OF LASERS AND LASER INVENTORY

The LSO shall conduct an inventory of all lasers, in accordance with applicable regulations and standards, which shall be registered with OHS by the completion of the Registration form (see next page). Similarly, alterations and design changes that affect the hazard associated with a particular device will be documented on a registration form.

ALGONQUIN COLLEGE

LASER REGISTRATION FORM

REGISTRATION OF LASERS
(Use one form for each laser)

Responsible Holder:____

Office Location: __________________________ Tel.: ______________ Ext. _______
Building Room no.

Location of Laser: ____
Building Room no.

A) CONTINUOUS OUTPUT POWER: _______________________________

Laser Class: ____

Wavelength Range: ___________________ Wavelength: _________

Beam Diameter at Aperture: ____mm Beam Divergence: ____mrad
(At time of purchase)

B) PULSED OUTPUT POWER: ___________________________________

Laser Class: ____

Pulse Duration: _____________Frequency of Repetition: _____

Wavelength Range: ____________________ Wavelength: ________

Name of Users: ____

____

Signature of Responsible Holder: _______________________________

PLEASE RETURN COMPLETED FORM TO: **Safety and Security Services**
Attn: Mike Benkie
"G" Building

11.0 TRAINING

11.1 Student Laser Safety Training

The administration of the program shall establish and maintain, in accordance with the LSO an adequate laser safety-training program. Laser safety training shall be completed prior to admitting students to an area where laser radiation is present at the Class 3b or Class 4 levels is possible. Students that are expected to work with a Class 2 or Class 3a laser should be briefed on the hazards of direct beam viewing of the laser output. Students working with or viewing demonstrations with Class 3b or Class 4 lasers shall receive detailed instruction (Comprehensive Training) on safety procedures applicable to the lasers they are using. These safety instructions should be presented separately from the instructions on how to perform the experiment and shall include beam and non-beam hazards.

11.2 Faculty and Staff Laser Safety Training

The LSO and program administration shall ensure that the proper training is provided to faculty and staff who use Class 3b and Class 4 lasers or laser systems for teaching and laser demonstrations. Where applicable training shall include beam and non-beam hazards. The faculty or staff member who introduce the students to lasers have both the responsibility and the unique opportunity to establish the safety atmosphere in which the laser or laser system will be used. The tone this person sets can positively influence students' attitudes towards laser safety for the future. Therefore, it is critical that each faculty and staff member involved receives appropriate laser safety training so as to understand and communicate the proper regard for laser safety.

11.3 Comprehensive Training

The LSO will ensure that all individuals using Class 2, Class 3a, Class 3b, and Class 4 lasers, complete a comprehensive training program, which reviews the following topics:

- Fundamentals of laser operation (physical principles, construction, etc)
- Biological effects of laser radiation on the eye and skin
- Standard Operating Procedures (SOP's)
- Laser protective equipment
- Laser signs and labels
- Emergency procedures in case there is an accident

12.0 MEDICAL SURVEILLENCE

The purpose of a medical surveillance program is to establish accurate baseline records and / or monitor the health of workers. In accordance with ANSI standards, the medical surveillance required for laser workers consists only of pre-assignment ocular examinations. These examinations are required for laser workers who work directly with or around Class 3b and 4 lasers or laser systems. In the event of a suspected injury, an ocular examination must also be conducted. It is the responsibility of the department manager / chair to ensure medical surveillance is conducted and appropriate records are maintained.

12.1 Pre-assignment Medical Examinations

The purpose of the pre- assignment exam is two-fold. The first is to establish a baseline, in the event there is an accidental injury. The second is to identify workers who might be at special risk to chronic exposure from selected continuous-wave lasers. Eye examinations must be arranged by department managers or chairs and conducted prior to a laser worker commencing work with a class 3b or 4 laser.

12.2 Terminal Examinations

Terminal medical examinations may be undertaken at the discretion of the manager/chair, in instances where it is necessary to ensure adverse health effects have not arisen as a result of the laser worker's academic or employment activities.

12.3 Types of Examination

As per baseline examination protocol recommended by ANSI, the following tests will be conducted for all laser personnel, including students:

- (a) Ocular History
- (b) Visual Acuity
- (c) Macular Function
- (d) Colour Vision

Where all the responses are normal, no further examination is required. For individuals whose ocular function in any of the above (a to d) test is not normal, referral will be made to the ophthalmologist for Examination of the Ocular Fundus with an Ophthalmoscope.

12.4 Frequency of Eye Examination

Eye examination is required for all Laser Workers. It should be conducted prior to participation in laser work and following any suspected laser injury. Periodic examinations are not required.

12.5 Suspected or Known Laser Injury

Any employee with a suspected laser eye damage must contact the LSO and Safety and Security Services

13.0 CONTROL MEASURES FOR LASERS

Summary of Control Measures for Lasers and Laser Systems

Engineering Controls	Administrative and Procedural Controls	Personnel Protective Equipment
Protective housings and service panels	Laser safety officer	Eyewear
Interlocks on protective housings	Standard operating procedures	Clothing
Door Interlocks and remote control connectors	Limitations on use by laser class	Gloves
Beam attenuators and beam shutters	Entry limitations for visitors	
Keyswitches or padlocks	Education and training	
Filtered viewing optics and windows	Maintenance and service manuals	
Emission delays	Marking of protective devices	
Warning lights and emission indicators	Warning signs and labels	
Beam enclosures		
Laser-controlled areas		
Beamstops		
Remote firing and/or monitoring		

13.1 ENGINEERING CONTROLS

Commercial laser products will be certified by the manufacturer and will incorporate some engineering controls. Additional controls such as those shown below are required in order to reduce the potential for hazard associated with some applications of lasers and laser systems.

In some circumstances, such as research and development , some of these controls may impracticable. In such cases, the LSO shall effect a hazard analysis and ensure that control measures are instituted to assure safe operation.

*Engineering Control Measures Summary	Classification					
	1	2a	2b	3a	3b	4
Protective Housing	X	X	X	X	X	X
Without protective housing	LSO shall establish controls					
Interlocks on Protective Housing					X	X
Service Access Panel Interlocked and Marked					X	X
Key Control						X
Viewing Portals reduce light below MPE			X	X	X	X
Collecting Optics reduce light below MPE	X	X	X	X	X	X
NHZ established for Open Beam Path					X	X
Remote Interlock Connector						X
Beam Stop or Attenuator						X
Activation Warning Systems						X
Emission Delay						X
Labels	X	X	X	X	X	X
Area Posting					X	X
Laser Control Area					X	X
Laser Control Area (Temporary Repair)	X	X	X	X	X	

MPE = Maximum Permissible Exposure
NHZ = Nominal Hazard Zone
* See following pages for details

13.1.1 *Protective Housing*

A protective housing is a physical barrier preventing laser radiation in excess of the MPE from exiting the laser.

13.1.2 *Laser Use without Protective Housing*

In some circumstances, e.g. research and development and manufacturing operation without protective housing may be necessary. In these cases, the Laser Safety Officer shall assess the hazard and ensure that appropriate controls are instituted. The controls may include (but are not limited to):

- access restriction
- eye protection
- area controls
- barriers, shrouds, beam stops
- administrative and procedural controls
- education and training

13.1.3 *Interlocks on Protective Housing*

An interlock system which is activated when the protective housing is opened during operation and maintenance. The interlock prevents access to laser radiation above the applicable MPE.

13.1.4 *Service Access Panels*

Portions of the protective housing which are intended to be removed from any laser by service personnel only and permit direct access to Class 3b or 4 laser radiation shall either: (1) be interlocked (fail-safe interlock not required), or (2) require a tool for removal and shall have an appropriate warning label on the panel.

13.1.5 *Key Control*

A master switch which is operated by a key, or by a coded access (such as a computer code).

13.1.6 *Viewing Portals and Display Screens*

All viewing portals and display screens included as an integral part of a laser or laser system shall incorporate a suitable means (such as interlocks, filters, attenuators) to maintain the laser radiation at the viewing position at or below the applicable MPE for all conditions of operation and maintenance.

13.1.7 *Collecting Optics*

All collecting optics (such as lenses, telescopes, microscope, endoscopes, etc.) intended for viewing use with a laser or laser system shall incorporate suitable means (such as interlocks, filters, attenuators) to maintain the laser radiation transmitted through the collecting optics to levels at or below the appropriate MPE, under all conditions of operation and maintenance.

13.1.8 *Beam Paths*

Control of the laser beam path shall be accomplished as described in the following sections:

13.1.9 *Totally Unenclosed Beam Path*

Where the entire beam path is unenclosed, a laser hazard analysis shall be effected to establish the NHZ if not furnished by the manufacturer.

13.1.10 *Limited Open Beam Path*

Where the beam path is confined by design to significantly limit the degree of accessibility of the open beam, a hazard analysis shall be effected to establish the NHZ.

13.1.11 *Enclosed Beam Path*

When the protective housing requirements are temporarily relaxed, such as during service, the LSO shall effect the appropriate controls. These may include a temporary area control and administrative and procedural controls.

13.1.12 *Remote Interlock Connector*

The remote interlock connector, such as a “Panic Button”, deactivates or reduces the accessible radiation below the MPE on entry to an area protected.

13.1.13 *Beam Stop or Attenuators*

The beam stop or attenuator is a device capable of preventing access to laser radiation in excess of the appropriate MPE level when the laser or laser system output is not required.

13.1.14 *Laser Activation Warning System*

An audible system e.g. an alarm, a warning light (visible through protective eyewear), or a verbal “countdown” command during activation or start-up of the laser.

13.1.15 *Emission Delay*

A warning system which provides sufficient time prior to emission of laser radiation to allow appropriate action to be taken to avoid exposure to the laser radiation.

13.1.16 *Equipment Labels*

All commercial lasers are labelled. Homemade lasers, except Class 1, must have a label (with laser sunburst symbol) affixed to a conspicuous place on the laser housing or control panel.

13.1.17 *Area Posting Signs* *(see Fig. 4 (i),(ii))*

An area which contains a Class 3b or 4 laser or laser system shall be posted with the appropriate sign. A
notice sign shall be posted outside a temporary laser controlled area.
Signage can be obtained from the LSO.

13.2 ADMINISTRATIVE CONTROLS

Administrative and procedural controls are methods or instructions which specify rules, or work practices, or both, which implement or supplement engineering controls and which may specify the use of personal protective equipment. The Table below indicates the College requirement which is consistent with ANSI requirements for Class 3b and Class 4 lasers or laser systems.

Control Measures*	**Laser Classification**					
Administrative Controls	1	2a	2	3a	3b	4
Written Standard Operating Procedures					O	X
Output Emission Limitations				LSO determination		
Operator Training			O	O	X	X
Serviced by Authorized Personnel					X	X
Written Alignment Procedures			X	X	X	X
Eye Protection, if MPE is exceeded					X	X
Skin Protection, if MPE is exceeded					X	X
Spectator Control					O	X
Warning Signs and Labels (see Fig.4)			O	O	X	X
Modification of Laser Systems	LSO will reclassify					

X = Shall
O = Should
LSO = Laser Safety Officer

13.2.1 *Standard Operating Procedures (SOP's)*

Written SOP's shall be maintained with the laser equipment for reference by the operator, and maintenance or service personnel.

13.2.2 *Output Emission Limitations*

If, in the opinion of the LSO, excessive power or radiant energy is accessible during operation or maintenance of , the LSO shall take such action as required to reduce the levels of accessible power or radiant energy to that which is commensurate with the required application.

13.2.3 *Operator's Training*

Education and training shall be provided for operators, maintenance or service personnel prior to the commencement of work. The level of training shall be commensurate with the level of potential hazard. Below are the <u>recommended topics</u> to be included in a laser safety training program:

- Laser fundamentals
- Bioeffects of laser radiation on the eye and skin
- Relations of specular and diffuse reflections
- Nonradiation hazards (electrical, chemical etc.)
- Laser classifications
- Control measures: protective equipment, signage etc.
- Overall management and employee responsibilities

Where applicable, training shall include cardiopulmonary resuscitation (CPR) and electrical safety.
The LSO shall ensure that CPR skill is accessible.

13.2.4 *Authorized Personnel*

Lasers shall be operated, maintained or serviced only by authorized personnel.

13.2.5 *Written Alignment Procedures*

Alignment shall be performed in such a manner that the primary beam, or a specular or diffuse reflection of a beam, does not expose the eye to a level above the applicable MPE. Written SOP's outlining alignment methods shall be available.

13.2.6 *Eye Protection*

Eye protection shall be administratively required and their use enforced when engineering or other procedural and administrative controls are inadequate to eliminate potential exposure in excess of the applicable MPE.

13.2.7 *Spectators*

Spectators shall not be permitted within a laser controlled area unless:

(1) appropriate approval from the supervisor has been obtained.
(2) the degree of hazard and avoidance procedure has been explained.
(3) appropriate protective measures are taken.

14.0 PERSONAL PROTECTIVE EQUIPMENT

14.1 Eye Protection

Within the NHZ, eye protection (e.g. goggles, face shields, prescription eyewear using special filter or coating) is required and its use is to be enforced by the supervisor when engineering controls may fail to eliminate potential exposure in excess of the applicable MPE. It is important to select eye protection specifically for the wavelength and power of the particular laser.

The amount of attenuation offered by the eye protection is measured by OPTICAL DENSITY (OD) . The OD is given by the equation:

$OD = \log (\Phi_i / \Phi_t)$ where Φ_i is the incident power on the eye protector
Φ_t is the power transmitted through the eye protector

since the power transmitted must not exceed the MPE,

$OD = \log (E_o / MPE)$ where E_o is the power of a laser beam (through the appropriate aperture) before it strikes the eye protector, expressed as W/cm^2 or J/cm^2.

Therefore, the greater the OD, the greater the attenuation (less light will reach the eye).

14.2 Laser Protective Eyewear Requirements

1. Laser protective eyewear is to be available and worn by all personnel within the Nominal Hazard Zone (NHZ) of Class 3b and Class 4 lasers where exposures above the Maximum Permissible Exposure (MPE) can occur.

2. All laser protective eyewear shall be clearly labelled. The associated wavelength dependent transmissive properties of the eyewear must be available to the user.

3. Laser protective eyewear shall be inspected for damage periodically and prior to use.

APPENDICES

Appendix A.

LASER CONTROLLED AREA

The following items are required for the various types of laser control areas:

Class 3b Laser Controlled Area:

1. Posted with the appropriate warning sign(s).
2. Operated by qualified and authorized personnel.
3. Under the direct supervision of an individual knowledgeable in laser safety.
4. Located so that access to the area by spectators is limited.
5. Have any potentially hazardous beam terminated in a beam stop of an appropriate material.
6. Have personnel within the controlled area provided with the appropriate eye protection if there is any possibility of viewing the direct or reflected beams.
7. Where possible, have the laser secured such that the beam path is above or below eye level of a person in any standing or seated position.
8. Have all windows, doorways, open portals, etc. from an indoor facility be either covered or restricted in such a manner as to reduce the transmitted laser radiation to levels at or below the appropriate ocular MPE.
9. Ensure appropriate steps are available to prevent unauthorized use.

Class 4 Laser Controlled Area:

1. Fulfil all items of Class 3b Control areas and in addition incorporate the following:
2. Personnel who enter a Class 4 controlled area shall be adequately trained, provided with the appropriate protective equipment, and follow all applicable administrative and procedural controls.
3. Fire exits and entryway shall be designed to allow both rapid egress by laser personnel at all times and admittance to the laser controlled area under emergency conditions.
4. For emergency conditions, appropriate means shall be available (e.g. “Panic Button”) for deactivating the laser or reducing the output to the appropriate MPE levels.
5. Ensure that controls are in place to prevent unexpected and unauthorized entry into the laser controlled area. These controls may be non-defeatable, defeatable or procedural as determined by the LSO following ANSI Z136.1-2000.

Temporary Laser Controlled Area

Where removal of panels or protective housings, over-riding of protective housing interlocks, or entry into the NHZ becomes necessary (such as for service), and the accessible laser radiation exceeds the applicable MPE, a temporary laser controlled area shall be set up. This control area shall provide all safety requirements for all personnel, both within and outside the area and shall be posted outside the temporary laser controlled area to warn of the potential hazard.

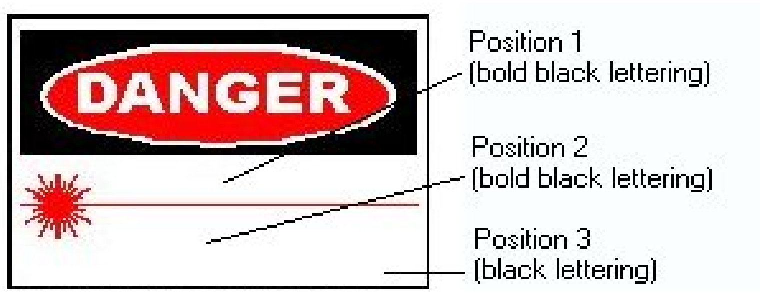


Fig. 6 (i) - Sample warning sign for certain Class 3a,3b and Class 4 lasers.
Position 1 states precautionary or protective instructions.
Position 2 describes the type of lasers, emitted wavelength, maximum output, and pulse duration if applicable.
Position 3 states the laser class.

Fig. 6 (ii)- Sample Temporary Laser Controlled Area sign.
This sign shall be posted outside a temporary controlled area, for example, during periods of service. The area outside the temporary controlled area remains Class 1, while the area within is either Class 3b or 4.

APPENDIX B

GENERAL LAYOUT OF LASER SAFETY SIGNS

Examples of typical laser signs are shown below in a typical 8.5-x 11-in. horizontal format. Signs shall be conspicuously displayed in locations where they best will serve to warn onlookers. A pragmatic alternative to expensive commercial or laminated signs are ones that can be generated and readily updated with very specific messages using a color printer and mounted in protective viewgraph sleeves. Signs should be approved by an LSO. Equipment labels follow basically a similar format as the signs described below.

Sign types. The DANGER sign is to be used to indicate an imminent hazard which, if not avoided, ***will*** result in serious injury or death. The CAUTION sign indicates a hazardous situation that ***could*** result in minor or moderate injury if not avoided. The WARNING sign may be used outside an area or an enclosure that contains a danger-level hazard. The ***hazard could potentially*** result in serious injury or death if not avoided. A WARNING sign is not a replacement for the required DANGER sign. The *NOTICE* sign indicates a statement related to personnel or property protection. It shall not be used solely in place of the previously mentioned signs.

Type format. The signal word shall be large type and in all uppercase letters (in this case 108 point), comparable in size to the safety-alert symbol. The word and symbol shall be on the same baseline. The text messages for Positions 1, 2, and 3 shall be 18 or 24 point, left justified using upper and lowercase black letters. Only words that need to be emphasized should be in all capital letters. Do not overfill the space with large type because sufficient "white space" makes the messages more readable. Both the signal word and the messages shall be in bold, sans-serif fonts (Helvetica or Geneva).

Panels and symbols. The upper colored, signal-word panel shall be red to signify DANGER, yellow for CAUTION, orange for WARNING and blue for *NOTICE*. The signal word type shall be white for DANGER and *NOTICE*, and black for CAUTION and WARNING. Note that only the *NOTICE* word is printed in italic font. The safety-alert symbol uses the corresponding colors as the colored panel; the exclamation point utilizes the same color as the panel; and the equilateral triangle uses the same color as the signal word. The safety-alert symbol is used only to indicate a potential personnel injury hazard. It should not be used to alert only potential property damage. Hence, the *NOTICE* sign does not use a safety alert symbol. The body of the sign may incorporate many different kinds of graphic symbols depending on the type of hazard. The examples below show only the laser sunburst symbol; it shall be black for all signs, except that the DANGER sign shall be red. The *NOTICE* sign may use a black or blue symbol. The backgrounds for all signs shall be white, except for the CAUTION sign, which uses yellow. In the latter case, the yellow background and signal word panel merge together.

Specific applications of laser-related signs. For the laser-class signs, the word message in Position 1 is verbatim from Section 4.7.4 of ANSI Z136.1-2000 and is based on the highest class of laser described by a sign. Use of the words invisible or visible, as appropriate, are added for any of the lasers covered. If a sign covers only visible lasers, the words visible laser radiation may be replaced by visible laser light. A separate paragraph at Position 1 can describe precautionary instructions. However, it is better to include it just below the sunburst at Position 2. This paragraph may include such messages as "Access for authorized individuals only"; "Minimum optical density (OD) eyewear may be required"; "Knock for access permission"; "Call x-xxxx for access"; etc. It should end with reference to an applicable OSP, FSP or IWS (see OSP xxx.xx) or (see IWS xxxxxxxx) as appropriate. The lower portion of Position 2 should describe either (1) laser type or wavelength, pulse duration (if appropriate) and maximum output; or preferably (2) laser type, OD requirement for maximum protection, applicable wavelength in nm. The latter format is preferred because the OD specification normalizes hazard levels that otherwise would require power (CW) or energy (pulsed), pulse duration and repetition rate as applicable, exposure duration, beam size, divergence, limiting aperture, as well as wavelength. The data should be presented in tabular form for ease of readability and should not be crowded with overly large type. Position 3 shall show the highest class of laser covered by a sign and be located at the lower right-hand corner.

Specific functions of signs are listed below

- A DANGER-Class 4 laser sign covers one or more Class 4 lasers that are considered to be at very high power or energy. Typically, a facility described by such a sign will require access interlocks unless other controls are implemented.

- A DANGER-Class 3b laser sign covers one or more Class 3b lasers that are considered to be of moderate to high power or energy. A facility described by such a sign may employ optional access interlocks, particularly if two or more lasers are in operation at the same time, unless other controls are implemented. Visible CW alignment lasers $\leq$15 mW and with appropriate beam control require no interlocks when they are the only lasers used.

- A DANGER-Class 3a laser sign covers one or more Class 3a lasers that are considered to be of moderate power or energy and exceed the maximum permissible exposure (MPE). Typically, a facility described by such a sign will not employ access interlocks.

- A CAUTION-Class 3a laser sign covers one or more visible Class 3a lasers that are considered to be of low power or energy and are expanded not to exceed the MPE when viewed without optical viewing aids for $\leq$0.25 s. This sign is seldom used. No interlocks are required.

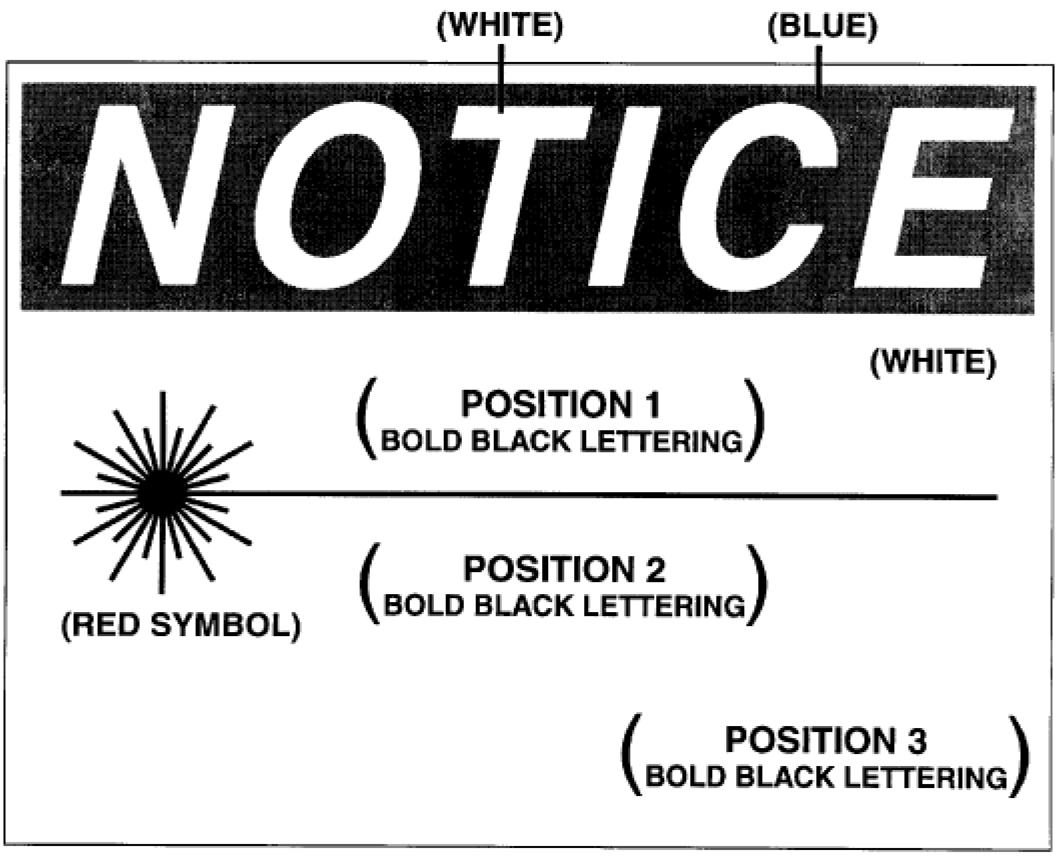
- A CAUTION-Class 2 laser sign covers one or more visible Class 2 lasers that are considered to be of low power and do not to exceed the MPE for $\leq$0.25 s. No interlocks are required.

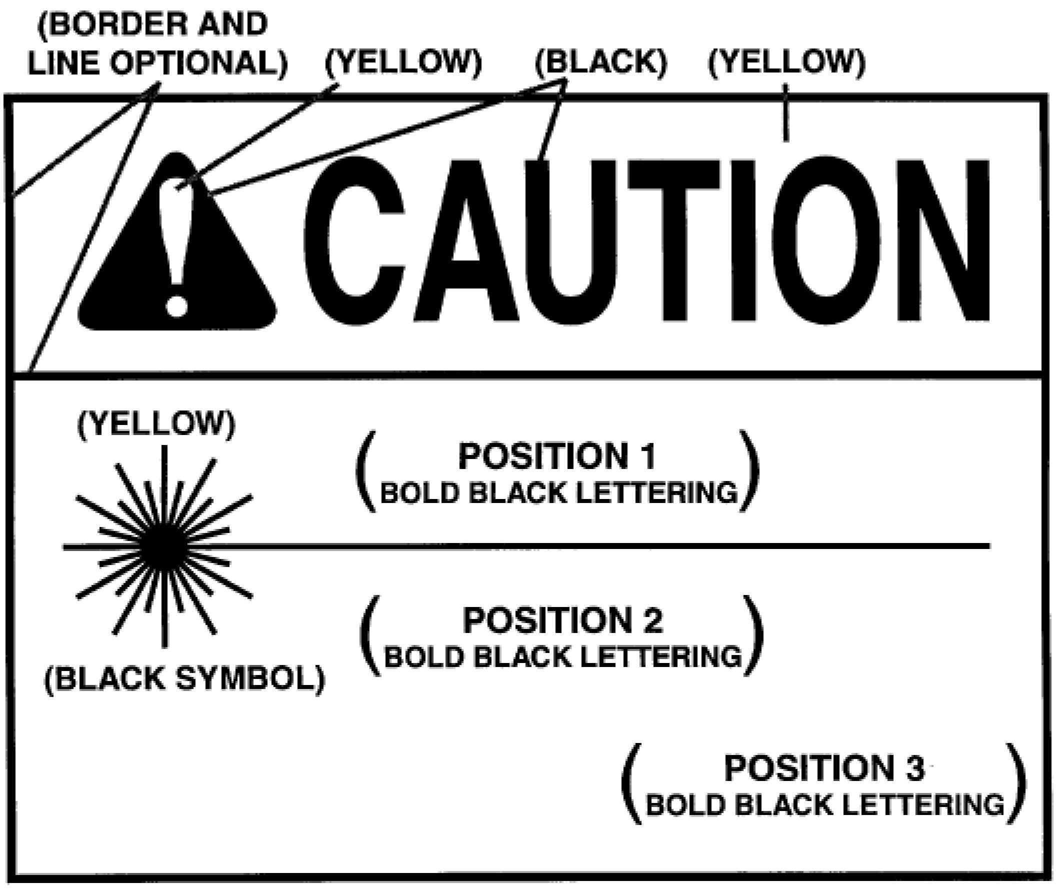
- A WARNING sign warns of potential harm behind a door or enclosure. It may be used to advise of an unattended operation; a high-power or high-energy laser completely embedded as a Class 1 laser; hazardous accessible electrical contacts within an enclosure, etc.

- A NOTICE sign is a policy sign conveying information directly or indirectly related to personnel or property protection. It may provide notification of inactivity of a facility, equipment, or an interlock system. It may also be used to advise of a temporary situation such as when a laser is being serviced without functioning interlocks. In the latter case, the *NOTICE* sign must be supplemented with the appropriate DANGER sign.

Figure A-1 Displays a generic sign with the following general characteristics (from top to bottom): at the top is a colored signal-word panel with a safety-alert symbol (exclamation point within an equilateral triangle) and a signal word; below this is a word message designated as Position 1; this is followed by a graphic symbol (in this case, a laser-sunburst symbol); positions 2 and 3 are final word messages. Older signs that conformed to ANSI standards shall remain valid; however, all new signs shall conform to the new sign standards described in ANSI Z535.x-1998 (x refers to standards 1, 2, 3, 4 and 5).

Warning Signs





(BORDER AND LINE OPTIONAL)
(YELLOW)
(BLACK)
(YELLOW)
CAUTION
(YELLOW)
(BLACK SYMBOL)
POSITION 1
BOLD BLACK LETTERING
POSITION 2
BOLD BLACK LETTERING
POSITION 3
BOLD BLACK LETTERING

Appendix C

ALGONQUIN COLLEGE

LASER INSPECTION FORM

Surveyors Name: ________________________ **Date of Inspection:** _____________
Location of Laser: ____
(Building) (Room)

Principal Investigator: ____________________________ **Ext:** _______________
Lab Contact: __________________________________ **Ext:** ________________

LASER POSTING, LABELLING AND SECURITY

		Yes	No	N/A
1.	Entrance properly posted with laser signs	___	___	___
2.	Is Adequate Security in place	___	___	___
3.	Interlock system in place and functioning	___	___	___
4.	Laser status indicator in place	___	___	___
5.	Laser class label posted	___	___	___
6.	Laser hazard label posted	___	___	___
7.	Laser aperture label in place	___	___	___

LASER UNIT SAFETY CONTROLS

8.	Protective housing in place	___	___	___
9.	Interlock on housing	___	___	___
10.	Interlock on housing operational	___	___	___
11.	Beam shutter present	___	___	___
12.	Key operation	___	___	___
13.	Laser activation indicator on console	___	___	___
14.	Beam power meter	___	___	___
15.	Emergency shutoff available	___	___	___

ENGNEERING SAFETY CONTROLS

16.	Laser secured to table	___	___	___
17.	Laser optics secured	___	___	___
18.	Laser not at eye level	___	___	___
19.	Beam is enclosed	___	___	___
20.	Beam barriers in place	___	___	___

		Yes	No	N/A
21.	Beam stops in place			
22.	Remote viewing of beam	___	___	___
23.	Beam condensed or enlarged	___	___	___
24.	Beam focused	___	___	___
25.	Beam intensity filtered	___	___	___
26.	Fiber optics used	___	___	___
27.	Windows in room covered	___	___	___
28.	Reflective materials not in beam path	___	___	___
29.	Check for stray beams	___	___	___
30.	Class 4 diffuse reflection hazard	___	___	___

ADMINISTRATIVE CONTROLS

31.	SOP's are kept up to date	___	___	___
32.	SOP's are posted	___	___	___
33.	Emergency contacts are posted	___	___	___
34.	All users have reviewed safety procedures	___	___	___

OTHER LASER SAFETY MEASURES

35.	Eye examination performed	___	___	___
36.	Proper eye protection is available	___	___	___
37.	Eye protection is being worn	___	___	___
38.	Proper skin protection is being used	___	___	___

NON BEAM HAZARDS

39.	Is toxic laser media in use	___	___	___
40.	Is hazardous media properly stored	___	___	___
41.	Is fume hood for dye mixing	___	___	___
42.	Are cryogens in use	___	___	___
43.	Is compressed gas in use	___	___	___
44.	Are gas cylinders in use	___	___	___
45.	All belts, pulleys and fans guarded	___	___	___
46.	Are there any high voltage power hazards	___	___	___
47.	Are electrical panels unobstructed	___	___	___
48.	Are optical tables grounded	___	___	___
49.	Are there collateral radiation hazards	___	___	___
50.	Are there any explosion or fire hazards	___	___	___

ADDITIONAL COMMENTS

____

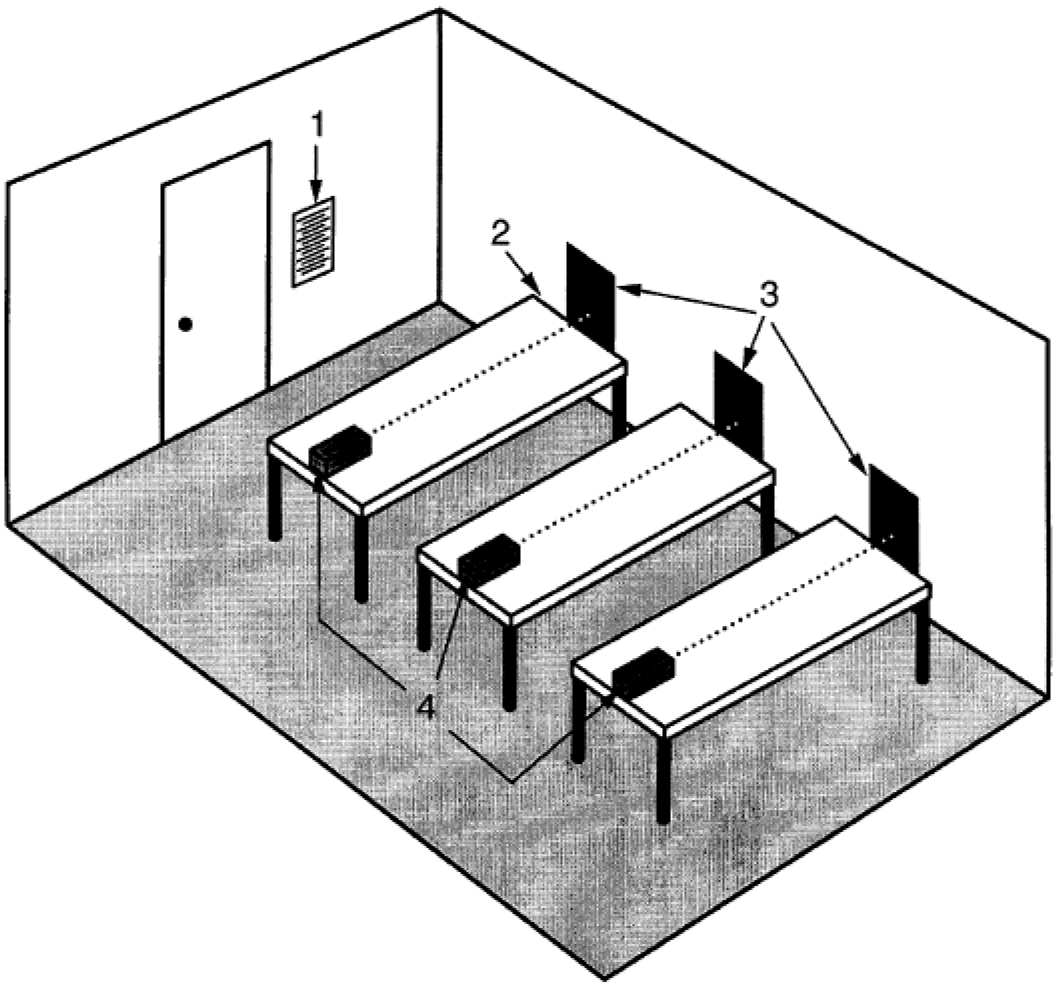
____

____

Appendix D

LASER LABORATORY LAYOUTS

Figure H1. Suggested Class 2 Laser Laboratory

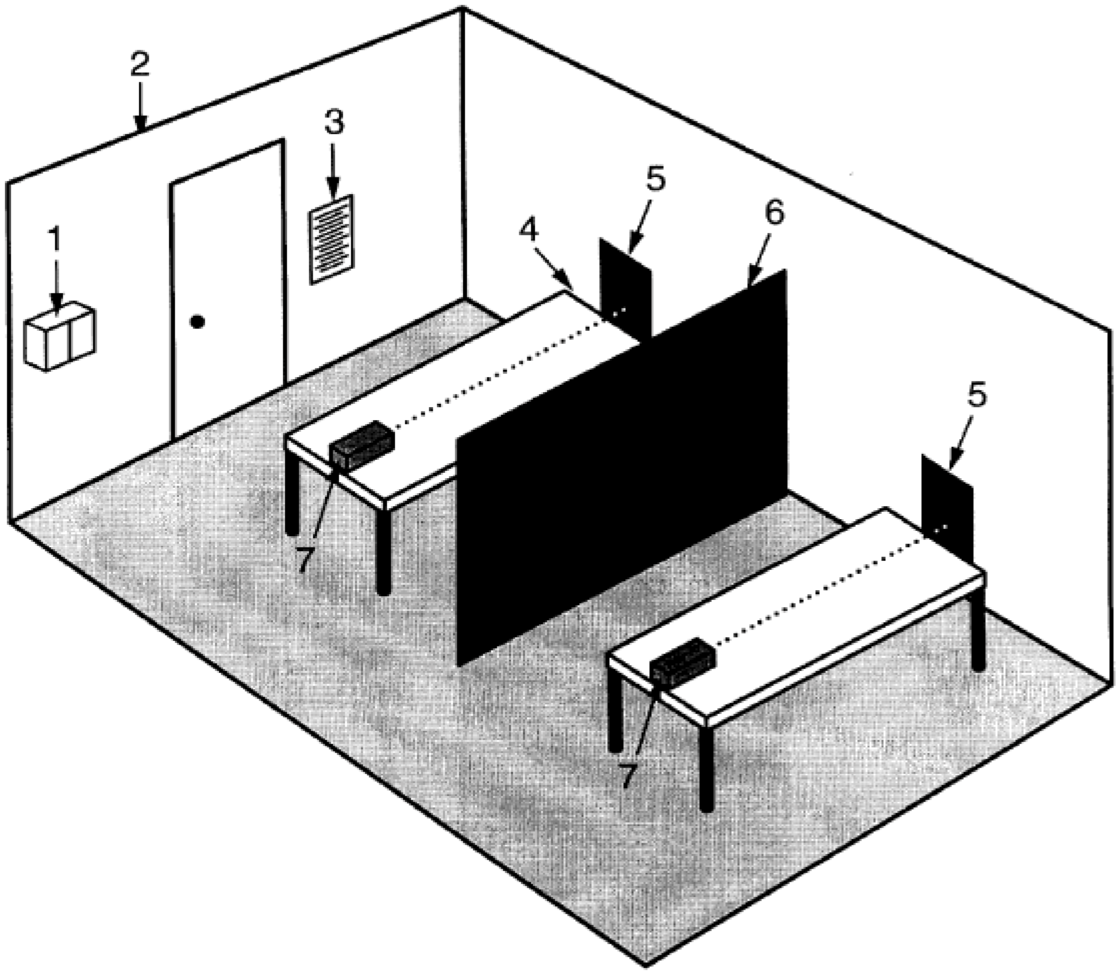


Legend:

1. Operating instructions
2. Benches against the wall to prevent students from looking into the beam
3. Beam stops to prevent reflection of the laser beam
4. Multiple class 2 lasers in the room

Appendix E

Figure H2. Suggested Class 3a Laser Laboratory

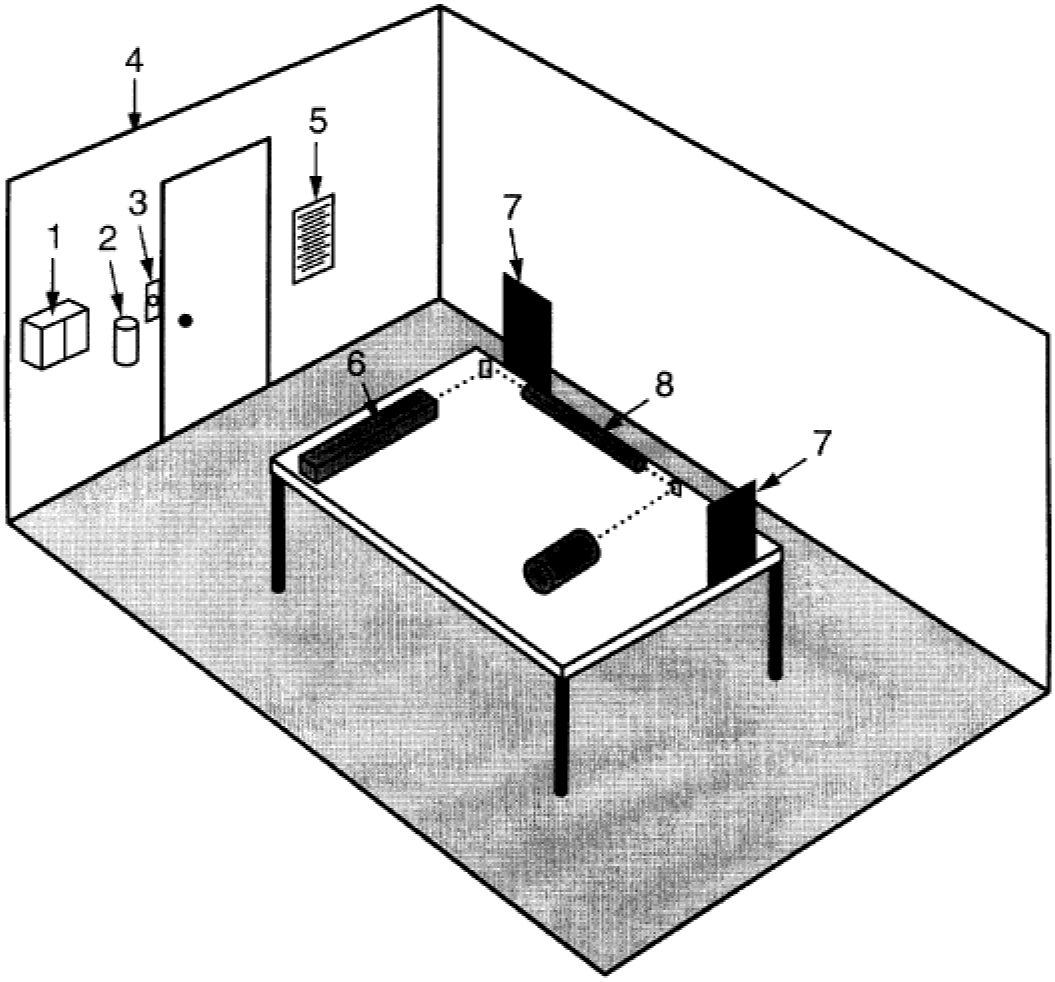


Legend:

1. Cabinet for safety glasses if necessary for alignment
2. Caution/Danger sign on the door
3. Operating instructions
4. Benches against the wall to prevent students from looking into the beam
5. Beam stops to prevent reflection of the laser beam
6. Wall separating laser stations
7. Multiple class 3a lasers in the laboratory

Appendix F

Figure H3. Suggested Class 3b and Class 4 Laser Laboratory



Legend:

1. Cabinet for safety goggles
2. Fire extinguisher
3. Door interlock override button
4. Danger sign on the door
5. Standard Operating Procedures
6. Only one Class 4 laser or laser system in the laboratory
7. Beam stops to prevent laser beam from leaving the optical table
8. Beam tube mounted on the table

REFERENCES

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2. ANSI Z136.5-2000 – American National Standard for Safe use of Lasers in Educational Institutions.
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