LASER SAFETY MANUAL

For

Columbia University

New York State Psychiatric Institute

Barnard College

October 2023

Contents

Foreword

The Research Laser Safety Program (the **Laser Safety Program)** of Columbia University **(Columbia** or the **University),** New York State Psychiatric Institute (**NYSPI)** and Barnard College (**Barnard**) serves to ensure the safe use of laser systems in accordance with government regulations, applicable institutional standards, and universal best practices. The Laser Safety Program reflects the fact that lasers emit non-ionizing radiation (ionizing radiation can be also emitted in some rare instances) and have a set of risks that must be addressed. Lasers are potentially hazardous unless used safely.

The Laser Safety Program at Columbia University is wide and integrated across all campuses (the Morningside campus (**Morningside**), Columbia University Irving Medical Center (**CUIMC**), the Manhattanville campus (**Manhattanville**), Nevis Laboratories (**Nevis**) and the Lamont-Doherty Earth Observatory (**Lamont**); it also includes laser safety at NYSPI and Barnard. However, the Laser Safety Program applies only to lasers used in research and does not cover the clinical use of lasers at New York Presbyterian Hospital (**NYP**). The Program is operated by the University's Office of Environmental Health and Safety (**EH&S)** and is overseen by a Laser Safety Committee **(LSC)** and a Laser Safety Officer.

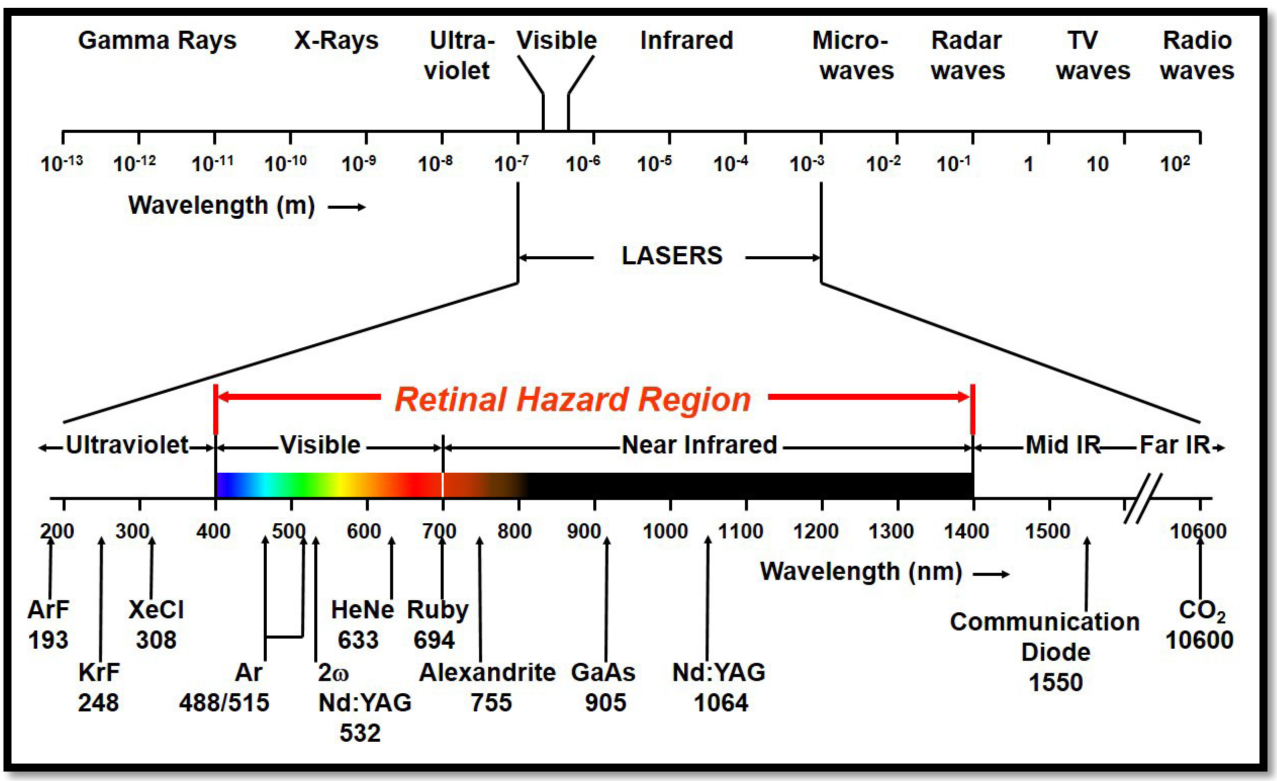
The principal guidance document for the Laser Safety Program is the Columbia University, New York State Psychiatric Institute and Barnard College Laser Safety Manual (this **Manual).**

The purpose of this Manual is to provide some background information on lasers and the biological effects of laser exposure, the regulatory framework of laser safety and the roles and responsibilities of the LSC and individuals active in the Laser Safety Program, as well as the authorizations and trainings that are required for laser users. It also provides detailed guidance on the safe use of lasers in research and requires that lasers and laser systems be operated in accordance with the American National Standards Institute (ANSI) Z136.1 2014, "The Safe Use of Lasers" (the **ANSI Laser Safety Standard)**.

I. Introduction

The word "laser" is an acronym for Light Amplification by Stimulated Emission of Radiation (**laser).** The theory of stimulated emissions was developed by Albert Einstein in the 1920's, but the operational use of lasers did not begin until the 1950's. There is a wide use of lasers today, in such applications as check out scanners, laser printers, laser light shows, industrial, medical and military uses, optical imaging, and microscopes. Research uses of lasers usually include optical imaging and microscopes.

The term "light" in reference to lasers is not limited to visible light. Laser radiation is emitted over a wide range of the electromagnetic spectrum from the ultraviolet region through the visible spectrum to the infrared region, but rarely in microwave or other wavelength ranges. The most frequently used unit in expressing a laser's wavelength is the nanometer (**nm).** The range of commonly available lasers is from 180 nanometers to 10.6 micrometers. The diagram below shows the operating wavelengths of some common types of lasers. Certain lasers may emit more than one wavelength.



*2ω = 2nd harmonic of Nd:YAG

Laser light is very different from normal light. Laser light has the following properties:

- The light released is **monochromatic.** It contains one specific wavelength of light (i.e., one specific color).
- The light is **coherent.** It is organized, as each photon moves in step with the others. This means that all of the photons have wave fronts that launch in unison.
- The light is very **directional.** A laser light has a very tight beam and is very strong and concentrated.

These properties occur because of **stimulated emission,** i.e., photon emission is organized because a photon encounters another atom that has an electron in the same excited state as the first photon.

There are three principal operational modes of lasers:

- Continuous wave;
- Single pulsed; and
- Repetitively pulsed.

Continuous wave (**CW**) lasers emit a constant beam of laser energy, while pulsed lasers emit a short, concentrated packet of energy, and require a recovery period (from a fraction of a second to minutes or longer) before another pulse can be released. Pulsed lasers may be more dangerous than continuous wave lasers. As the pulse duration decreases, the peak power or concentration of energy increases. If the length of the pulse is short compared to the time needed to transfer heat energy, the result could be a rapid temperature rise or ablation of material.

Q-switching is a mechanism for solid state lasers that is used for producing extremely short (~10-250 ns), high energy laser pulses. The Q-switch exists in the optical cavity of a laser, and consists of an extremely fast shutter. The usage of this technique allows for the storage high level laser energy. Once the shutter opens, it's able to emit this stored high energy with an extraordinarily high instantaneous power, which can make the laser more dangerous than other pulsed lasers operating without a Q-switch mechanism.

There are two forms of laser reflections that can have safety consequences: **specular reflection** and **diffuse reflection.**

Specular reflection is reflection of the beam off a flat, reflective surface such as a mirror, where the angle of reflection is equal to the angle of the incoming (or incident) light. This means that the overall beam quality is kept intact and the energy and wavelength remain the same, but the direction of the travel of the light is changed and reflected like a mirror. Specular reflection can be caused by inadvertent reflection off a shiny reflective surface. The same damage (for instance, to the eye) can be produced by the reflected beam as well as the original beam.

Diffuse reflection is reflection of the beam off an uneven surface, so that the photons are scattered in different directions, spreading the beam out in a less concentrated form. Diffusely reflected beams will lose coherence and therefore have many different energies and wavelengths. This reduces the chance of eye and tissue damage, except that if the laser is powerful enough, diffuse reflection can still be damaging.

II. Regulations and Standards

A. Code of Federal Regulations

As provided for by the Radiation Control Health and Safety Act of 1968, manufacturers of lasers must comply with the Federal Laser Product Performance Standard **(FLPPS)** established pursuant to Title 21 (Food and Drugs), Subchapter J (Radiological Health), Parts 1010 and 1040 of the CFR. In particular, the FLPPS defines the different classes of lasers based on the potential safety risks that different types of lasers represent and imposes certain safety measures on manufacturers of lasers, such as labeling lasers with specific warnings. The FLPPS applies only to manufacturers and not to users.

B. U.S Occupational Safety and Health Administrations (OSHA)

Laser safety in an occupational setting is regulated by OSHA. Although OSHA does not have a specific standard for lasers (with the exception of some requirements for construction practices that are not applicable to research use of lasers), safe work practices are required under the General Duty Clause **(GDC)** that states that employers must give employees a workplace that is “free from recognized hazards that are likely to cause death or serious harm”. Under the GDC, OSHA guidance recognizes the ANSI Laser Safety Standard that governs the safe use of lasers as representing the industry standard. The University has committed to follow the ANSI Laser Safety Standard.

C. Laser Safety Standard Laser Classification

The ANSI Laser Safety Standard describes the following classification of lasers based on their capacity to cause injury to human beings. The laser manufacturer is responsible for providing the laser classification at the time it was purchased. The PI is responsible for the classification of the lasers built or modified in their lab, after consultation with the LSO.

Class 1 Lasers and Laser Systems (Exempt Lasers)
These lasers are very low power (<1 microWatt **(µW))** such that they can be considered to be incapable of causing injury. Also, Class 1 laser systems may contain higher class lasers within them; if the laser is fully enclosed with adequate protection and therefore not a risk to users, it can be redefined as a Class 1 Laser system. Some examples of Class 1 Lasers are laser printers, CD players, DVD devices, geological survey equipment, and laboratory analytical equipment. Injury during normal operation is virtually impossible for a Class 1 Laser and therefore no safety requirements are imposed when equipment is used as intended. Modifying or disassembling any component of Class 1 system may expose the user to a greater level of hazard, and should not be permitted.

Class 1M Lasers and Laser Systems
These lasers are considered to be incapable of producing hazardous exposure conditions during normal operation unless the beam is viewed with collecting optics (e.g telescope, eye loupes,

lenses). They are exempt from any control measures other than to prevent potentially hazardous optically aided viewing.

Class 2 Lasers and Laser Systems (Low Power Lasers)
These lasers are low power (<1 mW) lasers that only operate in the visible spectrum of wavelengths (400-700 nm). Some examples of Class 2 Lasers are laser pointers, aiming devices and range finding equipment. They are unlikely to cause injury because of the natural human aversion (i.e., blink) response (eye reaction in <0.25 seconds). If viewed directly for a long time or with certain optical aids, they could be hazardous. Class 2 laser systems are exempt from any control measures except for conditions of intentional direct viewing of the beam.

Class 2M Lasers and Laser Systems
These lasers are low power (<1 mW) lasers that always operate in the visible spectrum of wavelengths (400-700 nm). Eye protection is normally afforded by the aversion response; however, Class 2M lasers are potentially hazardous if viewed with colleting optics. Class 2M laser systems are exempt from any control measures except for conditions of intentional direct viewing of the beam and/or potentially hazardous optically aided viewing.

Class 3R Lasers and Laser Systems (Moderate Power Lasers)
These lasers are continuous wave (**CW),** intermediate power (1-5 mW) devices. Class 3R Lasers have similar applications to Class 2 Lasers, with the most popular uses being laser pointers and laser scanners. A Class 3R beam is potentially hazardous under some direct and specular reflection viewing conditions if the eye is appropriately focused and stable, but the probability of a serious or permanent injury is small.

Class 3B Lasers (Moderate Power Lasers)
These lasers are intermediate power (5-500 mW) devices. Some examples of Class 3B Laser uses include spectrometry, stereolithography, and entertainment light shows. Direct viewing of the laser beam is hazardous to the eye and specular reflection of the beam could also be hazardous to the eye; these lasers are normally not a diffuse reflection or a fire hazard.

Class 4 Lasers (High Power Lasers)
These lasers are high power (>500 mW) devices. Some examples of Class 4 Laser uses are surgery, research, drilling, cutting, welding, and micromachining. Class 4 Lasers can be hazardous to the skin and the eyes during direct exposure, as well as exposure due to specular and diffuse reflection. Class 4 Lasers can also be a fire or air contaminant production hazard.

Class 3B and Class 4 lasers require the approval of appropriate control measures by the Laser Safety Officer in order to reduce the risk of a hazardous exposure. The control measures are divided into three categories: engineering, administrative (procedural), and PPE.

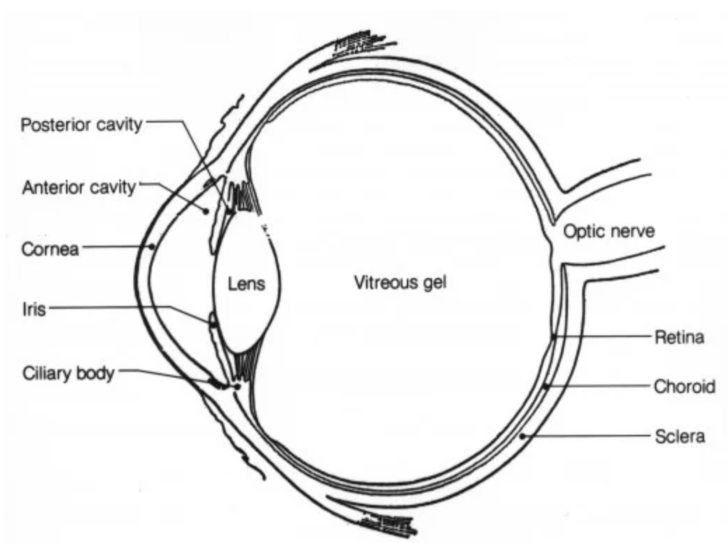
III. Laser Hazards

A. 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. The direct beam, diffuse reflection, or specular reflection from a laser can damage the eye and skin.

Eye Hazards

The eye consists of three main structures that can be significantly damaged by interactions with laser energy: the cornea, the lens, and the retina. Each of these structures can be seen in the diagram below:



The eye is vulnerable to short-term or permanent injury if exposed to laser radiation. The location and extent of injury depends on the wavelength and the energy absorption characteristics of the ocular media. Lasers cause biological damage by depositing heat energy in a small area, or by photochemical processes. Infrared, ultraviolet, and visible laser radiation are capable of causing damage to the eye. Corneal opacities (cataracts) or retinal injury may be possible from chronic, as well as acute, exposures to excessive levels of either visible or invisible laser radiation. There are three main eye injuries that can occur: Thermal injuries, Photochemical injuries, or Microcavities (Retinal Explosions). The following tables summarizes the different eye injuries:

Laser-Tissue Interaction	Characteristics
Thermal Burn	• Caused by elevated temperature after absorption of laser energy. • Injury to both eyes and skin at all wavelengths. • Dominant eye injury for Continuous Wave lasers.
Retinal Explosion (Microcavities)	• Explosive effect when short pulses are absorbed in the retina. • Dominant eye injury for short pulsed visible and Near-Infrared Lasers. • Results in severe vision loss.
Photochemical	reactions in tissues after absorption of high energy sult in cataracts or skin cancer. nd skin at wavelengths less than 600 nm. blue and UV wavelengths for exposures greater than 10

<table>
<tr><th>Photobiological spectral domain</th><th colspan="2">Eye effects</th></tr>
<tr><td>Ultraviolet C (0.200-0.280 µm)</td><td colspan="2">Photokeratitis (cornea)</td></tr>
<tr><td>Ultraviolet B (0.280-0.315 µm)</td><td colspan="2">Photokeratitis (cornea)</td></tr>
<tr><td>Ultraviolet A (0.315-0.400 µm)</td><td colspan="2">Photochemical UV cataract (lens)</td></tr>
<tr><td>Visible (0.400-0.780 µm)</td><td>Photochemical and thermal retinal injury</td><td rowspan="2">Retinal Hazard Region</td></tr>
<tr><td>Infrared A (0.780-1.400 µm)</td><td>Cataract, retinal burns</td></tr>
<tr><td>Infrared B (1.400-3.00 µm)</td><td colspan="2">Corneal burn, aqueous flare, IR cataract</td></tr>
<tr><td>Infrared C (3.00-1000 µm)</td><td colspan="2">Corneal burn only</td></tr>
</table>

Eye hazards are easily controlled by using laser safety eyewear that is appropriate for the specific laser system, or by other engineering safety controls. The ANSI Laser Safety Standard recommends **maximum permissible exposure (MPE)** limits on the basis of retinal damage thresholds and light concentration by the lens. The MPE values are based on several factors, including wavelength, visibility, and exposure time. The MPE values are less than known hazard levels. However, exposures at MPE values may be uncomfortable to view. It is good practice to maintain exposure levels as far below the MPE values as practical.

Skin Hazards

Along with eye damage, skin effects can also occur with exposure to laser radiation. Depending on the wavelength, power output, and duration of exposure, skin effects could range from a mild skin reddening to an advanced blistering or charring. With the use of UV lasers, exposures carry the risk of different skin cancers. For the various wavelengths of the electromagnetic spectrum, the following table summarizes the associated skin effects that could possibly occur with hazardous beam exposure.

Photobiological spectral domain	Skin effects
Ultraviolet C (0.200-0.280 µm)	Erythema (sunburn), skin cancer
Ultraviolet B (0.280-0.315 µm)	Accelerated skin aging, increased pigmentation
Ultraviolet A (0.315-0.400 µm)	Pigment darkening, skin burn
Visible (0.400-0.780 µm)	Photosensitive reactions, skin burn
Infrared A (0.780-1.400 µm)	Skin burn
Infrared B (1.400-3.00 µm)	Skin burn
Infrared C (3.00-1000 µm)	Skin burn

Shielding the beam and reflections or covering the skin with opaque materials will help prevent skin effects.

B. Non-beam hazards

Non-beam hazards are important and their risk of occurrence increases with the power output of the laser. Laser users shall be mindful about non-beam hazards, since they can be potentially fatal. Non-beam hazards may occur when a target material is exposed to a laser beam, when materials used to generate the beam are released into the atmosphere, or when individuals contact system components (e.g., electrocution). Therefore, non-beam hazards shall not be underestimated and shall be taken very seriously, especially when working with Class 4 lasers.

Laser Generated Air Contaminants (LGAC)

Air contaminants may be generated when certain laser beams (most likely for Class 4 lasers) interact with matter. Carcinogenic, toxic and noxious airborne contaminants can be liberated if the target material is likely to be exposed to irradiances exceeding 10^7 W cm^{-2}. In these cases, proper ventilation of the area should be established, in consultation with the Laser Safety Officer, before the initiation of the experiment.

Fire

Combustible material such as paper and cardboard boxes can be ignited by the beam. Other potential fire hazards include electrical components and the flammability of Class 4 Laser beam enclosures, if they are likely to be exposed to irradiances > 10 W cm^{-2} or beam powers exceeding 0.5 W. Under some situations where flammable compounds or substances exist, it is possible that fires can be initiated by class 3B lasers as well. The risks of fire can be reduced by using only fire-resistant materials (e.g., IFR curtains) near directed and scattered laser beams.

Curtains in any laboratory space are required to meet certain minimums of flame resistance. Although it is acceptable to buy curtains treated with a flame-resistant chemical, this is not recommended due to the required maintenance. Inherently Flame Resistant (**IFR**) curtains are more appropriate for the laboratory setting as curtains made from IFR materials do not require maintenance. Furthermore, any fabric used in a laboratory, whether treated with a flame-resistant chemical or IFR, requires the filing of an affidavit certifying the material's flame resistance with the Fire Department of New York City (FDNY). EH&S can provide this service and it is recommended that laboratories consult with Laser Safety Program personnel before purchasing any materials that are to be used as laser curtains. Nevis and Lamont are not bound to this certification requirement, as they do not fall under the jurisdiction of the FDNY, but they are inspected to provide an equivalent level of safety.

Electrical Hazards

This is the most common non-beam hazard. Potentially lethal electrical hazards may be accessible in a laser system, particularly in high-powered lasers. High voltage components such as power supplies and discharge capacitators may present an electrical hazard. High voltage equipment should be appropriately grounded. The use of any malfunctioning laser should be immediately discontinued. As with any device that produces a high voltage, extreme caution and diligence is needed to ensure that electrical shocks do not occur.

"Lock-out/Tag-out" procedures should always be observed when using high voltage equipment. These procedures ensure that hazardous equipment is properly and completely shut down before any repair or maintenance work begins, and that equipment remains in a de-energized state, eliminating the risk of contact with live electrical parts. Proper lock-out/tag-out procedures include de-energization of the equipment at its power source, and placement of a protective lock at the switch to prevent unauthorized start-up. To complete the "tag-out", a tag indicating the date and time that the device has been locked out, and identifying the user that has the key is attached to the lock. The tag notifies others how to contact the lock owner to remove the lock from the equipment. Properly applying lock-out/tag-out practices will allow work to be completed on the unit without any chance for accidental start-up and injury.

Hazardous Chemicals

Some material used in laser systems, especially gases and chemical solutions, may be hazardous or toxic substances. In addition, laser induced reactions may produce hazardous particles or gases around the laser system. If access to these materials is required, special care must be taken. For instance, laser dyes shall be prepared in a fume hood.

IV. Roles and Responsibilities

The primary oversight responsibilities within the Laser Safety Program rest with the LSC, the Laser Safety Officer and the Laser Safety Program personnel in EH&S. Together, they establish policies and procedures, oversee regulatory compliance, monitor Laser Safety Program performance and support the highest quality research. The Principal Investigators (**PIs**) and laser users also have responsibilities under the Laser Safety Program. The following briefly describes their roles and responsibilities.

A. Laser Safety Committee (LSC)

The purpose of the **LSC** is to administer the Laser Safety Program. The members and Chair of the LSC are appointed by the University's Executive Vice President for Research and Executive Vice President for Health and Biomedical Sciences, the Director of NYSPI and the President of Barnard. The membership of the LSC includes (a) at least one PI from each of Morningside, CUIMC, Manhattanville, Nevis, NYSPI, Barnard and Lamont (b) a representative from EH&S and (c) the Laser Safety Officer. The LSC has the following responsibilities:

- Establishing and maintaining laser safety policies and guidelines;
- Reviewing and approving updates to this Manual;
- Reviewing reports regarding laser safety audits and Program performance;
- Recommending corrective measures in instances of noncompliance;
- Establishing guidelines for the suspension of use of lasers in instances of noncompliance;
- Reviewing training requirements, materials and compliance;
- Reviewing the adequacy and effectiveness of laser safety controls; and
- Overseeing and approving new laser installations.
- Reviewing issues/incidents reported by the LSO or laser users.

B. Laser Safety Officer

The Laser Safety Officer is the staff member within EH&S designated to lead the Laser Safety Program. He/she reports to the LSC regarding the technical and policy matters of the program, and has the following responsibilities:

- Coordinating and managing the Laser Safety Program on a day-to-day basis;
- Executing the established policies of the Laser Safety Program and ensuring compliance with federal, state and local regulations;
- Supervising laser control activities as required by the LSC;
- Reviewing and approving registrations for Class 3B and Class 4 Laser use;
- Halting operations and involving lasers if unsafe or unacceptable conditions exist;
- Reviewing laboratory operations to determine compliance with the Laser Safety Program;
- Suspending use of lasers in accordance with the guidelines established by the LSC; and
- Maintaining records of Program operations that are suitable for inspection by regulatory authorities.
- Performing laser hazard analysis and recommending appropriate control measures.
- Investigating laser safety incidents.

C. Laser Safety Program Personnel

Laser Safety Program personnel are staff within EH&S who are assigned duties under the direction of the Laser Safety Officer, and have the following responsibilities:

- Recommending revisions to this Manual to the Laser Safety Officer and the LSC;
- Conducting periodic inspections of laser areas to recommend action for compliance with the requirements of the ANSI Laser Safety Standard;
- Assisting with the proper selection of Personal Protection Equipment (**PPE**);
- Upon request, assisting PIs or their staff with writing Standard Operating Procedures (**SOPs**);
- Providing training to laser users;
- Responding to all inquiries on laser safety procedures and providing technical assistance; and
- Maintaining records of laser inventories, audits, survey forms and training attendance.

D. Principal Investigator (PI)

A PI has the following responsibilities:

- Supervising all laser activities in his/her laboratory;
- Enforcing safe work practices outlined in this Manual;
- Developing and drafting SOPs for Class 3B and Class 4 Laser use;
- Maintaining and updating, as needed, all operating, alignment and emergency procedures for lasers and laser facilities;
- Ensuring registration of all Class 3B and Class 4 lasers (See Appendix A) and personnel who operate them;
- Maintaining an up-to-date list of all laser devices, facilities and users and communicating such list to Laser Safety Program personnel;
- Ensuring that personnel using lasers have attended Laser Safety Training prior to operating a laser;
- Performing and documenting work area specific training for all laser users prior to initial operation;
- Ensuring that any exposure to lasers remains below the MPE values;
- Ensuring that the PPE recommended by the manufacturer for safe operation of a laser is available and is used by all employees and visitors to the laser facilities;
- Supervising personnel in and visitors to the laser facilities to ensure against unauthorized entrance or accidental exposure;
- Designating a knowledgeable person to (a) notify the Laser Safety Officer and EH&S of any changes in operational status, such as location, purchases of and modifications to laser equipment, (b) revise SOPs in accordance with any modifications, (c) update all records, and (d) re-register a modified laser;
- Ensuring that all laser users have reviewed manufacturers' instructions for safe operation prior to the use of a laser; and
- Reporting all incidents involving safety violations to the Laser Safety Officer.

E. Laser Users

Any person using laser equipment has the following responsibilities:

- Becoming familiar with the laser equipment and the potential hazards that are associated with its use;
- Wearing all PPE designated by the PI;
- Inspecting eyewear prior to use to ensure that it is in good condition;
- Complying with this Manual and any SOPs relevant to the laser and laser facility used by the laser user;
- Completing the required initial and refresher training;
- Reporting laser hazards, including possible exposure to the beam, to the PI; and
- Maintaining a safe environment for researchers and students in the laboratory;

V. Training

A. Initial Training

Initial laser safety training must be completed by all personnel using Class 3B or Class 4 lasers prior to beginning any work with lasers, through the Rascal online course: *TC1600: Laser Safety Training.* The module includes instruction on:

- The biological effects of laser radiation;
- The physical principles of lasers;
- Beam and non-beam hazards
- Classification of lasers;
- Control of laser areas;
- Laser safety best practices;
- Laser user's responsibilities;
- Basic safety rules;
- Use of PPE; and
- Emergency response procedures.

B. Lab-specific Training

The above training covers general concepts of laser safety and does not cover specific details of the safe operation for each type of laser that may be encountered or used in the laboratory. Therefore, in addition to the general laser safety training, system-specific safety training should be provided, by the PI or a designated senior laser user, to all new laser users before they start working with a laser. The on-the-job training would include a thorough review of the hazards associated with each laser that a person may operate, the protection methods employed by the laboratory, and the emergency contacts.

The PI is responsible for ensuring that all members of his/her staff who will be using lasers have received the classroom training and the laser system specific safety training before they are allowed to operate a laser.

C. Refresher Training

Refresher training is required every two years and may be completed by taking the Rascal online course: *TC1600: Laser Safety Training (www.rascal.columbia.edu).*

VI. Procurement and Approval

A. Procurement

When purchasing a Class 3b or Class 4 Laser, the following process applies:

- The PI must complete a Laser Registration Form providing a description of the laser specifications (manufacturer, model, class, wavelength, pulsed/continuous wave, power, etc.), location of intended use, PI's laboratory emergency contacts, etc.
- The form should be emailed to the Laser Safety Officer at lasersafety@columbia.edu.
- The Laser Safety Officer approves the laser registration form, and returns it to the PI.
- The PI uploads the approved form into the ARC Portal System and marks the order as containing laser equipment.
- The Laser Safety Officer approves the requisition in ARC and Procurement proceeds with the laser purchase (if the PI does not submit a laser registration form, Procurement will contact the Laser Safety Officer to determine if the Form is required; laser registration Forms and the Laser Safety Officer's approval are not required for the purchase of lasers below Class 3B).

A copy of the Laser Registration Form is attached as **Appendix A.**

If a laser system is obtained by a method **other than purchase** (i.e., a gift or transfer from another institution), contact the Laser Safety Officer to complete the Laser Registration Form.

B. Inventory

EH&S maintains an inventory of all Class 3b and Class 4 Lasers at the University, NYSPI, and Barnard**.** A description of modifications to a laser that has either been purchased from an outside vendor or fabricated by a PI should be sent to EH&S to update the general inventory.

VII. Transfer and Disposal

A. Transfer

A PI must report the transfer of any laser to another laboratory at the University, NYSPI, or Barnard, so that the EH&S database can be updated. All laser systems that are purchased or built in a University, NYSPI, or Barnard laboratory and transferred to an external location in a manner that could be considered “in commerce” must meet the federal certification requirements. The University’s Office of General Counsel (**OGC**) will determine if those requirements apply.

B. Disposal

Certain types of lasers use organic solvents and toxic dyes. These waste materials must be collected and disposed of as hazardous waste through EH&S. Waste solvent/dyes should be collected in compatible containers (usually polypropylene) and labeled with the hazardous waste label as soon as the first material is added to the container. Do not attempt to evaporate waste in a fume hood to reduce the volume, or to drain dispose of the waste. Laser systems that do not contain any hazardous material may be disposed as general electronic waste.

The disposal of any laser must be reported to the Laser Safety Officer so that the inventory may be updated. For any questions regarding laser disposal, contact the Laser Safety Program personnel for support and guidance.

C. Laboratory Vacating and Closure

Before a PI who uses a laser departs from the University, NYSPI, or Barnard he/she should contact the Laser Safety Officer for guidance. The PI is responsible for disassembling the laser set-up and packing it appropriately for the move. The Laser Safety Officer will remove the laser from the inventory.

D. Off-Campus Use

Laser use off campus is governed by the same policies described above. The Principal Investigator shall inform the LSO of any Class 3B, or 4 lasers used off campus for research projects. The application and operation of the laser system(s) shall be evaluated by the LSO to ensure:

- Appropriate safety measures are in place prior to operation.
- Appropriate training for field use.
- Compliance with appropriate federal, state and local regulations.

VIII. Safe Use of Lasers

In order to ensure the safe use of lasers, control measures commensurate with the hazards must be devised to reduce the possibility of exposure of the eyes or the skin to hazardous levels of laser radiation and to mitigate indirect hazards. The following are general safety procedures that should be used with any Class 3B or Class 4 Laser:

A. Class 3B Laser Controls

- Do not work with or near a laser unless you have been authorized to do so.
- Do not enter a room or area where a laser is being energized unless authorized to do so.
- Before energizing a laser, verify that prescribed safety devices for the unit are being properly employed. These may include opaque shielding, non-reflecting and/or fire resistant surfaces, goggles and/or face shields, door interlocks and ventilation for toxic material.
- Make sure that a pulsed laser unit cannot be energized inadvertently.
- Do not stare directly into the laser beam at any time, even with eye-protection in place.
- Use appropriate eyewear during beam alignment and laser operation. Beam alignment procedures should be performed at the lowest practical power levels. When alignment has been completed, the laser output can be adjusted to the experiment requirements.
- Control access to laser facility. This can be done by clearly designating personnel who have access to the laser room. Implement access control by locking the door and installing warning lights or signs on the outside of the door.
- For invisible laser beams, use viewing cards or lower class visible lasers to define the beam path during alignment.
- Never leave a laser unattended when it is in operation.
- Remove any jewelry or other reflective objects to avoid inadvertent reflections.
- Enclose as much of the beam path as possible. Even a transparent enclosure will prevent an individual from placing his/her head in the beam path. Terminations should be used at the end of the useful paths of the direct beam and any secondary beams.
- Shutters, polarizers, and optical filters should be placed at the laser exit port to reduce the beam power to the minimal useful level.
- A warning light or buzzer should indicate laser operation. This is especially needed if the beam is not visible (i.e., for infrared lasers).
- Operate the laser only in a restricted area – for example, in a closed room without windows. A warning sign must be placed on the door.
- Place the laser beam path well above or well below the eye level of any sitting or standing observers whenever possible. The laser should be mounted firmly to assure that the beam travels only along its intended path.
- Always use proper laser eye protection if a potential eye hazard exists for the direct beam, or a specular reflection.
- A key switch should be installed to minimize tampering by unauthorized individuals.

- The beam or its specular reflection should never be directly viewed with optical instruments such as binoculars or telescopes without sufficient protective filters.
- Remove all unnecessary mirror-like surfaces from the vicinity of the laser beam path. Do not use reflective objects such as credit cards to check beam alignment. Note: the reflectivity of an object is a function of the wavelength of the laser beam.

B. Class 4 Laser Controls

In addition to the controls above, the following are controls that should be used with Class 4 Lasers:

- These lasers should only be operated within a localized enclosure, in a controlled workplace. If a complete local enclosure is not possible, indoor laser operation should be in a light-tight room with interlocked entrances to assure that the laser cannot emit energy while the door is open. However, under special conditions where an interlocked door could interfere with proposed research activity, an alternate method of protection such as a curtain or a barrier should be discussed with EH&S to provide a suitable barrier just inside the door or where ever most appropriate to intercept a beam or scatter it so that a person entering the room could not be exposed above the MPE limits.
- Appropriate eye protection is required for all individuals working within the controlled area.
- If the laser beam irradiance is sufficient to be a serious skin or fire hazard, suitable shielding should be used between the laser beam and any personnel or flammable surfaces.
- Remote firing with video monitoring or other remote (safe) viewing techniques should be chosen when feasible.
- Beam shutters, beam polarizers, and beam filters should always be used to limit use to authorized personnel only. The flash lamps in optical pump systems should be shielded to eliminate any direct viewing.
- Backstops should be diffusely reflecting fire resistant target materials where feasible. Safety enclosures should be used around micro welding and micro drilling work pieces to contain hazardous reflections from the work area. Microscopic viewing systems used to study the work piece should ensure against hazardous levels of reflected laser radiation back through the optics.

Engineering controls should be the first line of defense to mitigate laser hazards. Enclosure of the laser equipment or the beam path should be the preferred method of control, since the enclosure will isolate the hazard. The set-up of the laser beam is crucial for the determination of the potential hazards. If a PI has applied any appropriate engineering controls, the system can be re-classified as a Class 1 laser (with Laser Safety Officer approval). All engineering controls and laser set-ups should be approved by the Laser Safety Officer.

C. Laser Alignment Considerations

Although laser injuries are uncommon, laser operators must be especially mindful about their safety during laser alignment procedures. A laboratory must include written alignment procedures as part of its SOPs. Fluctuation of beam intensity and direction might occur for several reasons, thus regular beam alignment control may be required. During alignment, laser users tend to be closer to the beam, remove some engineering controls and rotate the system's optics. Therefore, the probability of the beam interaction with the eye or unprotected surfaces is higher. It is important to know that most laser injuries occur during beam alignment. Things to keep in mind are the following:

- Turn down the beam power to the minimum needed in order to do the alignment.
- If the beam is invisible, utilize viewing cards or infrared viewers.
- Make sure only authorized personnel are present in the laser area.
- Communicate with others present in the same room that you plan to initiate alignment procedures.
- Remove any unnecessary reflective and flammable objects (including jewelry and ties) from the laser bench top.
- Make sure all present personnel are wearing the appropriate laser safety eyewear. In many occasions, special eye-protection shall be considered for alignment. These glasses do not block the laser beam fully, but a fraction of the beam can be transmitted through them, which allows partial visibility of the beam within acceptable levels (< MPE level).
- If the laser system has a built-in, low power alignment laser, use that feature instead of the main beam.
- Contain the beam as much as possible in order to complete your laser alignment safely without exposure to the beam.

IX. Personal Protective Equipment (PPE)

A. Protective Eyewear

The ANSI Laser Safety Standard requires that protective eyewear be worn when working with Class 3B and Class 4 lasers and whenever hazardous conditions may result from laser radiation or laser related operations. These glasses attenuate the intensity of laser light while transmitting enough ambient light for safe visibility. No single lens material is useful for all wavelengths or for all laser exposures. In choosing protective eyewear, careful consideration must be given to the operating parameters, MPEs, and wavelength. To minimize confusion, protective eyewear should be marked with its protective rating such as effective wavelength and optical density (**OD**). The OD characterizes the ability of the eyewear lens to filter and reduce the intensity of laser light transmitted to interact with the human eye. The mathematic expression of OD(λ) is the logarithm to the base ten of the reciprocal of the transmittance at a particular wavelength:

$OD(\lambda) = -\log_{10} \tau(\lambda)$ where $\tau(\lambda)$ is the transmittance at the wavelength of interest.

Therefore, if you have an OD of 1, it reduces the transmittance by a factor of 10; if you have an OD of 2 it reduces the transmittance by a factor of 100 (and so on). The higher the OD the higher the attenuation.

The Laser Safety Program personnel maintain a list of approved laser safety eyewear manufacturers and can provide recommendations regarding the appropriate eye-protection for each laser use. See **Appendix B.**

It is extremely important that laser users wear the appropriate laser safety eyewear correctly. For example, only eyewear such as goggles specifically designed to fit over prescription glasses may be worn with prescription glasses. In addition, prescription laser safety glasses are readily available from most vendors of laser safety eyewear. Be mindful that general safety glasses, contact lenses, or sunglasses are not considered laser protective equipment.

B. Skin Protection

Although skin injuries are generally less serious than eye injuries, skin injuries may still occur, especially during beam alignment. In cases where the use of engineering controls cannot fully enclose the laser beam, a flame-resistant lab coat may fulfill the requirement, although tightly woven, flame-retardant fabrics provide the best protection for Class 4 lasers. Most gloves will provide some protection against scattered laser radiation, although opaque, flame-retardant gloves provide the best protection for Class 4 lasers.

There are very limited studies of the interactions between laser radiation and protective clothing. Even when wearing protective clothing (i.e. a laboratory jacket), it is not permitted to place any portion of your body in the beam path, or in the path of a specular reflected beam.

X. Warning Signs and Labels

A. Laser Lab Signage

Entrances to laser areas must have signage posted in accordance with the ANSI Laser Safety Standard. The laser controlled areas must be secured against accidental exposure to beams and be posted with a proper warning sign. An illuminated warning sign outside of the area is recommended, preferably flashing and lit only when the laser is on. Also, all windows, doorways and portals should be covered or restricted to reduce transmitted laser beam below the MPE.

Class 3B Laser facilities must have a “Warning” signs conspicuously displayed. Class 4 Laser facilities must have a “Danger” sign conspicuously displayed. See **Appendix C** for examples of these signs. Laser safety door postings are provided by Laser Safety Program personnel upon request.

For open beam Class 4 lasers, the ANSI Laser Safety Standard require interlocked doors (sensors or pressure sensitive doormats), or devices that turn-off or attenuate the laser beam in the event of unexpected entry into the area. However, under special conditions where an interlocked door could interfere with the research activity, an alternate method of protection such as a laser curtain or a barrier, should be discussed with the Laser Safety Officer. With a laser curtain or barrier, the hazardous beam would be intercepted or scattered, so that a person entering the room will not be exposed above the MPE limits.

B. Laser Alignment Sign

When laser alignment is in progress, a temporary sign describing the hazard and warning users not to enter should be placed on all entrances to the lab. These signs should be in place <u>only</u> during alignment and removed as soon as alignment is complete.

C. Laser System Labels

For manufactured lasers, the manufacturer is responsible for providing the classification of the laser at the time of purchase, and an appropriate label is attached. When lasers are constructed or modified in the laboratory, the PI is responsible for assigning the proper classification, with advice from the Laser Safety Officer. Laser warning labels for these lasers must be affixed to the equipment, near the point of emission. The contents of laser warning labels are specified in the ANSI Laser Safety Standard.

XI. Standard Operating Procedures (SOPs)

SOPs are recommended for Class 3B lasers and are required for Class 4 lasers within the University. The PI should prepare written SOPs, including Service and Maintenance Procedures, if these are performed by members of his/her research team, and the Laser Safety Officer should review and approve them. These written procedures shall be maintained with the laser equipment for reference by the laser users, and maintenance or service personnel. General exposure guidelines, special precautions, alignment procedures, required PPE, emergency contacts etc. should be outlined in the SOPs. A SOP template is included in **Appendix D**. The Laser Safety Officer can provide assistance and advice in the development of SOPs.

Laser incident reports continually demonstrate that an increased ocular hazard exist during alignment procedures. Therefore, Class 3B and Class 4 lasers and laser systems should have written standard operating procedures outlining the manner in which laser alignments will be conducted in order to minimize ocular hazards.

The manufacturer's manual for each laser should also be available to the laser users.

XII. Emergency Response

In the event that a laser user suspects that he/she has been injured by beam or non-beam hazards, he/she should notify the applicable PI and the Laser Safety Officer immediately. The PI should file a laser incident report with the Laser Safety Officer, who will complete an investigation and report to the LSC.

The ANSI Laser Safety Standard states that any employee with an actual or suspected laser-induced injury should be evaluated by a medical professional as soon as possible after the exposure and in any event within 48 hours of the exposure. For injuries to the eye, the laser user shall have an medical examination by an ophthalmologist, and for skin injuries the laser user shall be examined by a physician.

Emergency Medical Services by Campus

If the injured laser user needs medical attention, the following is the location and contact information for emergency medical services:

- Morningside: Saint Luke's Hospital Emergency Room, 1111 Amsterdam Avenue at 114th Street, (212) 636-3375. Students can also report to Student Health Services (**SHS**) located at 519 W 114th St.
- Manhatanville: Harlem Hospital, 506 Lenox Ave, (212) 939-1000
- CUIMC: Workforce Health and Safety, Harkness Pavilion first floor, (212)305-7580 on weekdays between 8am-4pm and the NYP Emergency Room at Broadway & 167th St. At all other times, affected students can also report to SHS located on 60 Haven Avenue, (212)305-3400
- Lamont: Nyack Hospital, 160 North Midland Ave, Nyack, (845) 348-2000
- Nevis: St. John's Riverside Hospital Dobbs Ferry Pavilion, 128 Ashford Ave Dobbs Ferry, (914) 693-0700

For a comprehensive guide of emergency procedures, please see the link below:
https://research.columbia.edu/sites/default/files/content/EHS/Homepage/EmergencyProceduresTable.pdf

XIII. Audits and Inspections

Laser Safety Program personnel will conduct annual internal audits in each laboratory that has a Class 3B or Class 4 laser system in operation. The audit will assess the safety culture and compliance with the ANS Laser Safety Standard and this Manual. Results of the audit will be communicated to the applicable PI, the Laser Safety Officer, and the LSC. Any deficiencies must be corrected, and corrective actions must be communicated to Laser Safety Program personnel.

Lasers that were manufactured as Class 1 systems but contain a higher class laser will not be subject to an audit. However, Class 3B or Class 4 lasers that have been enclosed or modified in the lab using engineering controls and determined by the Laser Safety Officer to be a Class 1 laser system will still be subject to an annual audit. A copy of the Laser Safety Audit Form is attached as **Appendix E**.

It is possible that an OSHA inspector may visit Columbia University anytime and review the safe use of lasers in our institution.

Appendix A

Laser Registration Form - Environmental Health & Safety (EH&S)

Principal Investigators **MUST** complete and sign a Laser Registration Form during the procurement process of a Class 3b or Class 4 laser. The Form should be forwarded to the Laser Safety Office at lasersafety@columbia.edu

(PLEASE TYPE OR PRINT)

PI NAME: ________________________ DEPARTMENT: ________________________

BUILDING/ROOM: __________________ EMERGENCY PHONE: ________________________

LASER LOCATION: BUILDING ____________________ FL/ROOM #: ________________________

Are safety signs posted on door? ☐ Yes ☐ No Are safety glasses/goggles used? ☐ Yes ☐ No

Are written SOP's developed? ☐ Yes ☐ No Are users trained on the SOP·? ☐ Yes ☐ No

Will laser curtains be used for this laser? ☐ Yes ☐ No

LASER DESCRIPTION: PLEASE DESCRIBE SPECIFICATIONS/CHARACTERISTICS OF THIS EQUIPMENT:

Type of laser:________________________________ Manufacturer: ________________________

Model:____________________________ SERIAL No: ________________________________

LASER CLASS: ☐ CLASS 3B ☐ CLASS 4

TYPES OF OPERATION: ☐ C.W. ☐ PULSED ☐ MULTIPLE PULSED

MAXIMUM POWER OR ENERGY OUTPUT:____________PULSE REPETITION FREQUENCY: _________

OPERATING WAVELENGTHS: ____

MAXIMUM EXPECTED EXPOSURE DURATION PER DAY ________________________________

OTHER PERTINENT INFORMATION:

IS LASER SERVICE DONE: IN HOUSE? ☐ YES ☐ NO CONTRACTED OUT ☐ YES ☐ NO

IF CONTRACTED OUT, COMPANY ____

______________________________ ____________________

REGISTRANT'S SIGNATURE DATE

______________________________ ____________________ ____________________

EH&S APPROVAL SIGNATURE DATE EHS Approval No.

Appendix B

LIST OF LASER PROTECTIVE EYEWEAR MANUFACTURERS AND VENDORS

Kentek Corp.
1-800-432-2323
https://www.kenteklaserstore.com/

Laservision
1-800-393-5565
https://www.lasersafety.com/

Innovative Optics
1-800-990-1455
https://innovativeoptics.com/

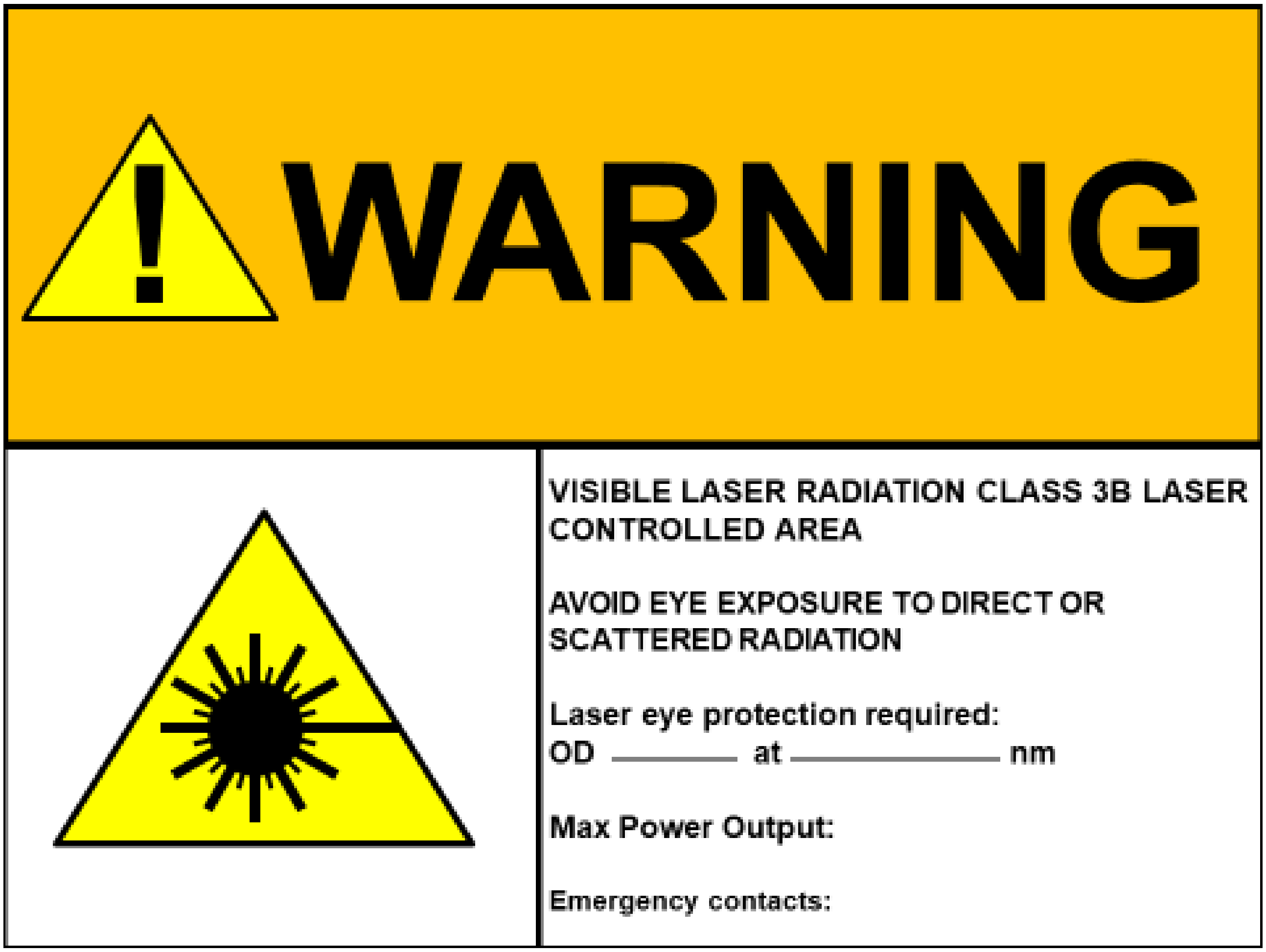
NOIR
1-800-521-9746
https://noirlaser.com/

Thor Labs
1-973-300-3000
https://www.thorlabs.com/

Appendix C


DANGER
VISIBLE AND/OR INVISIBLE LASER RADIATION
CLASS 4 LASER CONTROLLED AREA
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION
Laser eye protection required:
OD __________ at _____________ nm
Max Power Output:
Emergency contacts:

Appendix C


WARNING
VISIBLE LASER RADIATION CLASS 3B LASER CONTROLLED AREA
AVOID EYE EXPOSURE TO DIRECT OR SCATTERED RADIATION
Laser eye protection required:
OD ________ at ____________ nm
Max Power Output:
Emergency contacts:

Laser Standard Operating Procedures - Template

Standard Operating Procedures (SOPs) are required for class 4 and are recommended for class 3B laser systems by ANSI Z136.1 2014. This document represents a template of the SOPs related to the use of a laser system. It is intended to be a comprehensive guide of the laser's operation for all authorized users.
It is the responsibility of the Principal Investigator to complete this SOP and to ensure that it is followed by the laser users. The Laser Safety Officer (LSO) is available to provide guidance on SOP completion upon request.

The SOPs shall be provided to new laser users prior to laser operation and they should be reviewed periodically.

Laser System information			
Manufacturer/Model	Type of Laser (e.g DPSS, gas)	Class	Serial Number
Appendix D			

Laser Safety Training

Initial general laser safety training must be completed by all personnel using Class 3B or 4 lasers prior to starting any work with lasers. The Laser Safety Program offers classroom training to first-time users of lasers and to individuals who have had training and experience at other institutions.

In addition to the general laser safety training, a system-specific safety training should be provided by the PI or a designated senior laser user, to all new laser users before they start working with the laser. The on-job training could include a thorough review of the hazards associated with each laser that a person may operate, the protection methods employed by the laboratory and the emergency contacts. The level of training shall be commensurate with the degree of potential laser hazards, both from the laser radiation and non-beam hazards.

The PI is responsible for ensuring that all members of his/her staff who will be using lasers have received a) the classroom training and b) the laser system specific safety training before they are allowed to operate a laser.

Refresher training is required every two years and will be completed by taking the Rascal online course: *TC1600: Laser Safety Training. (www.rascal.columbia.edu)*

Laser safety contacts / Emergency contacts		
Title	**Name**	**Contact details**
Principal Investigator		
Laser supervisor		
Maintenance/repair		
EHS Emergency-LSO		

In each section below, select the applicable controls and describe the specific safety requirements, operations, procedures and other relevant details applicable to the laser system.

Emergency Procedures

Emergency Procedures		
Controls	Click if applicable	Comments
Do not remove the laser housing/electrical shock danger.	☐	
Push the emergency button to shut down the laser.	☐	
Use key switch to restart the laser.	☐	

Additional emergency procedures /Comments

Responsibilities of the Principal Investigator (PI)

A PI has the following responsibilities:

- Supervising all laser activities in their lab.
- Enforcing safe work practices outlined in the Laser Safety Manual ANSI and the Standards Z136.1;
- Developing and drafting SOPs for Class 3B and Class 4 Laser use;
- Maintaining and updating, as needed, all operating, alignment, and emergency procedures for the laser and laser facility;
- Ensuring registration of all Class 3B and Class 4 Lasers and personnel who operate them;
- Maintaining an up-to-date list of all laser devices, facilities, and users and communicating such list to Laser Safety Program personnel;
- Ensuring that personnel using lasers have attended Laser Safety Training prior to operating a laser;
- Performing and documenting work area specific training for all laser users prior to initial operation;
- Ensuring that any exposure to lasers remains below the Maximum Permissible Exposure (MPE) values;
- Ensuring that the personal protective equipment (PPE) recommended by the manufacturer for safe operation of the laser is available and is used by all employees and visitors to the laser facility;
- Supervising personnel in and visitors to the laser facility to ensure against unauthorized entrance or accidental exposure;
- Acting to or designating a knowledgeable person to (a) notify the LSO and EH&S of any changes in operational status, such as location, purchases, and modifications to laser equipment, (b) revise SOPs in accordance with any modifications, (c) update all records, and (d) re-register a modified laser;
- Ensuring that all users have reviewed manufacturers' instructions and the SOPs prior to the first use of the laser; and
- Reporting all incidents involving safety violations to the LSO.

Responsibilities of Laser Users

- Becoming familiar with the laser equipment and the potential hazards that are associated with its use;
- Wearing all PPE designated by the PI;
- Inspecting eyewear prior to use to ensure that it is in good condition;
- Complying with the Laser Safety Manual and any SOPs relevant to the laser facility used by the laser user;
- Completing the required initial and refresher biennial training;
- Reporting laser hazards, including possible exposure to the beam, to the PI; and
- Maintaining a safe environment for researchers and students in the laboratory.

Laser procedures: Pre-Start		
Controls	Click if applicable	Comments
User Manual is followed throughout laser operation.	☐	
Warning lights are on.	☐	
Laser warning signs are provided at entrances.	☐	
All individuals in the room are warned verbally prior to laser operation.	☐	
A controlled area is established prior to laser operation. All personnel remain outside of the control area during laser operations.	☐	
All objects that can affect the beam path or cause any hazards are removed.	☐	
Be aware of specular and diffuse reflections.	☐	
Obtain appropriate eyewear (correct wavelength and OD) or skin protection.	☐	
Remove jewelry and ties, and all loose or dangling clothing and objects.	☐	
Confirm by double-checking that all systems are in place before operationalizing the laser.	☐	
Turn the key control switch to the “ON” position and follow the manufacturer’s recommended steps.	☐	

Additional start-up procedures / Comments

Alignment procedures		
Controls	Click if applicable	Comments
Use of lower power lasers (Class 1,2,3R) for path simulation of 3B and 4 class (visible or invisible) lasers.	☐	
Exclude unnecessary personnel from the laser controlled area.	☐	
Appropriate eye and skin protection is available and worn during beam alignment.	☐	
Beam display devices, such as image converter viewers or phosphor cards are used to locate beams, during invisible laser beams alignment.	☐	
Verify lowest possible power level is used during laser alignment.	☐	
Beam blocks and/or protective barriers are used, where alignment could stray into uncontrolled areas, with unprotected personnel.	☐	
Shutters or beam blocks are used to terminate high power beams.	☐	
Beam blocks are placed behind optics to terminate beams that might miss mirrors during alignment.	☐	
All beams and reflections are properly terminated before high-power operation.	☐	

Additional alignment procedures / Comments

Control Measures		
Controls	Click if applicable	Comments
Laser is enclosed in a protective housing.	☐	
Interlocks are applied.	☐	
A master switch (key or coded access) is used to initiate and terminate the laser beam.	☐	
Viewing windows and diffuse display screens are used and maintain radiation levels below MPE.	☐	
Collecting optics (lenses, microscopes etc.) incorporate suitable means such as interlocks, filters, attenuators, to maintain radiation levels below MPE.	☐	
Visible or audible warning device **prior** to entering the laser's controlled area, is used.	☐	
Visible or audible warning device, usually a single red light located on the laser or its control panel, is used **within** the controlled area.	☐	Sounds that arise from auxiliary equipment (e.g fan) and are associated with the emission of laser beam, can be considered as audible warnings.
Visible warning device signal is visible through protective eyewear.	☐	
Establishment of laser's controlled area has been performed.	☐	
Beam path is above or below eye level in any standing or sitting position.	☐	

Curtain, screen, or blocking barrier, is used to prevent laser beam from exiting controlled area.	☐	
Class 3b and 4 lasers shall be operated, maintained, and serviced only by authorized personnel.	☐	
Spectators are permitted within the laser controlled area only with the approval of the laser supervisor.	☐	

For fully and limited open beam lasers, hazard analysis is performed by the LSO for the determination of the nominal hazard zone (NHZ). For enclosed beam lasers, the requirements of a Class 1 system are typically fulfilled and no further controls are required.

Additional control measures

Please provide a description of the exact procedure that you follow in order to start-up, operate and shut-down the laser system. If you just follow the instructions from the user manual then provide the page numbers. All laser users shall have easy access to the SOP and the user manual, therefore ensure that everyone knows their location.

Maintenance – Service

Maintenance refers to frequently required tasks, such as cleaning and replenishment of expendables. Maintenance may or may not require beam access. Service functions are usually performed with far less frequency than maintenance functions (these may include replacing the laser resonator mirrors or repair of faulty components) and may require access to the laser beam by those performing the service functions. Service functions are delineated in the service manuals of the laser or laser system. Service personnel shall have the education and safety training to apply service to the laser system. All enclosures, interlocks, and safety devices must be replaced and verified operationally prior to returning the laser to regular use.

Who is responsible for maintenance and service of the laser system?

I have read and understood the above procedures, my responsibilities as a user and the hazards that are associated with the laser operation. As an authorized user of this laser, I agree to operate the laser following the user's manual and the above procedures.

Name	Have you received hands-on training on this laser system?	Signature	Date

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

Columbia University Medical Center
Radiation Safety - Laser Audit

Date of Audit: ________________
Principal Investigator: ________________
Building: ________________
Floor/Room #: ________________

Audit Performed by: ________________________
Reviewed by: ________________________
Date Reviewed: ________________________

Manufacturer	Model	Type	Serial Number

Laser Registration or Appendix D

Personnel Qualifications

P	F	NA	
☐	☐	☐	Personnel who will use laser system are appropiately trained

Name	C.U.ID #	STATUS (student/staff/faculty)	Training Received (Initial/Refresher)

Comments: ____

Laser Safety Control Measures

P	F	NA	**Administrative and Procedural Controls**
☐	☐	☐	Columbia University Laser Safety Policy available/posted
☐	☐	☐	Operating Manual available
☐	☐	☐	Appropriate laser classification
☐	☐	☐	Written Standard Operating Procedures (SOP) available
☐	☐	☐	Written operating, maintenance, and alignment procedures kept with laser equipment
☐	☐	☐	Laser is registered with EHS
☐	☐	☐	Laser is included in the EHS inventory
☐	☐	☐	Laser made or modified on Campus registered with EHS
☐	☐	☐	Access limited to authorized users only
☐	☐	☐	Viewing cards for non-visible beam available
☐	☐	☐	Viewing cards are used for aligment procedures
☐	☐	☐	Operators do not wear watches, jewelry, and ties during laser operation

Comments: ____

P	F	NA	Labeling-Posting-Warnings
☐	☐	☐	Laser sign posted on lab door (Danger/Warning/Caution)
☐	☐	☐	Laser sign posted on lab door for invisible radiation (Danger/Warning/Caution)
☐	☐	☐	Visible Warning Device when laser is energized
☐	☐	☐	Audible Warning Device when laser is energized
☐	☐	☐	Laser label on housing (Danger/Warning/Caution)
☐	☐	☐	Label of laser classification on housing
☐	☐	☐	Label of laser characteristics on housing (power,wavelength)
☐	☐	☐	Manufacturer's certification label on housing
☐	☐	☐	Laser controlled areas within the lab posted
☐	☐	☐	Label for the laser aperture on housing
☐	☐	☐	High voltage warning label on housing

Comments: ____

P	F	NA	Personal Protective Equipment (PPE)
☐	☐	☐	Appropriate eye protection (goggles) available for laser use

Description	Wavelength - OD	S/N #	Condition (Free of damage/clean)	Date checked

☐	☐	☐	Warning lights can be seen through goggles
☐	☐	☐	Protection from diffuse UV radiation available (eyes/skin)
☐	☐	☐	Appropriate skin protection available/used (lab coats, long sleeved garments)

Comments: ____

P	F	NA	Engineering Controls for Beam Hazards
☐	☐	☐	Protective housing and interlocks in good condition
☐	☐	☐	Access/entrance to laser use rooms, is controlled to prevent accidental exposure to the laser beam
☐	☐	☐	Door interlock in good condition
☐	☐	☐	Beam stops present at the end of all beam paths
☐	☐	☐	Barriers/screens/black out curtains if present, are in use
☐	☐	☐	Laser table level below eye level for standing or sitting position
☐	☐	☐	Beam is not directed towards doors or windows
☐	☐	☐	Windows and ports are covered or protected during laser operation
☐	☐	☐	Surfaces minimize specular reflections
☐	☐	☐	Optical bench free of unnecessary reflective items
☐	☐	☐	Beam path enclosed when possible
☐	☐	☐	Controls are located so that the operator is NOT exposed to beam hazards
☐	☐	☐	Laser may be fired remotely
☐	☐	☐	All beams are traced

Comments: ____

P	F	NA	Non beam Hazards
☐	☐	☐	No exposed wiring or electrical circuits
☐	☐	☐	High voltage equipment appropriately grounded
☐	☐	☐	Laser beam is not impinging on flammable or combustible materials
☐	☐	☐	Barriers/screens/black out curtains are fire resistant
☐	☐	☐	Laser is operated so that it does not cause an explosion hazard
☐	☐	☐	Ventilation available to extract/scavenge metallic flumes, chemical vapors, and/or biological plumes
☐	☐	☐	Laser operation incorporates the safe use of compressed gases
☐	☐	☐	Laser operation incorporates the safe use of laser dyes

Comments: ____