Laser Safety

Standard Operating Procedures (SOP)

PRINCIPAL INVESTIGATOR:	**DATE:**
DEPARTMENT:	**COLLEGE/SCHOOL:**

Contents

Introduction

This document serves as a template for a written **Standard Operating Procedures (SOP)** for Class 3B and Class 4 laser(s). Responsible Principal Investigator (PI) must prepare one written SOP describing lab/laser specific procedures and precautions including the maintenance and alignment procedures for each Class 3B and/or Class 4 laser(s) in his/her inventory and submit it to **Laser Safety Officer (LSO)** for approval.

- Step-by-step detailed instructions for the safe use of laser must be listed for each laser separately in the **Lab-Specific Laser Safety Procedures** of the SOP, and must be available to all laser users and students, as applicable. These procedures must provide instruction on laser specific guidelines, special precautions, unusual conditions as well as login, system startup, routine maintenance, shutdown, logout and detailed alignment procedures, and including all safety-related steps and any data recording procedures that are related to radiation safety.
- The detailed written alignment procedures must also be posted in close vicinity of the laser. Refer to the attached **Alignment Procedures** for guidelines.

Principal Investigator

Operation of a Class 3B and/or Class 4 laser must be performed under the supervision of a PI whereby such operations must be first approved by the LSO. The approved PI can be a faculty or staff member who is knowledgeable in the operation of laser(s). All Class 3B and/or Class 4 laser(s) at Auburn University campus are subject to registration with LSO prior to possessing or operation of these lasers.

Principal Investigator's Responsibilities

PI and faculty of research laboratories and teaching facilities that employ Class 3B and/or Class 4 lasers have the following responsibilities:

- Register all Class 3B and/or Class 4 laser(s) with LSO using the attached **Laser Registration Form**. Complete one separate form for each laser in your current laser inventory and return all to LSO**.**
- Use this template to develop a written SOP describing your lab/laser specific procedures and precautions including the alignment procedures related to Class 3B and/or Class 4 lasers in your inventory. Complete **the Lab-Specific Laser Safety Procedures** in full detail and submit it to LSO for approval.
- Ensure no individual operates the laser in any manner other than that prescribed in the SOP.
- Identify all laser users with potential to use the laser or to be present during laser operations and assure that everybody receives both online **General Laser Safety Training** and **Site-specific/ On-the-job Training** prior to working in the lab. Complete the **Certificate of Training Form** for each laser user and maintain a copy of training documentation in the lab.
- Complete the **Laser Safety Self-Audit/Inspection Form** once a year, submit it to LSO to prepare for annual laser safety inspections.
- Post signs and inform personnel of both potential laser and non-beam hazards.
- Provide appropriate eye protection for persons working with Class 3B and/or Class 4 laser(s). For assistance in determining the appropriate optical density (OD), complete the **Laser Safety Hazard Evaluation Form** and return it to LSO.
- Contact LSO for approval if any procedure, maintenance or alignment requires access to the laser beam with any local component of the system disassembled or removed.
- Maintain all laser safety-related records (i.e., laser safety training, laser safety manual, inspections/ audits, incident/accident investigations for each employee).

Laser Safety Training

Only qualified and trained faculty, staff or graduate students may operate Class 3B and/or Class 4 lasers at Auburn University. To be qualified, a laser operator must meet both the training requirements outlined below, and operational qualifications established by the responsible PI. Laser Safety training must be provided consecutively before persons are permitted to operate lasers and or laser systems without supervision.

1. General laser safety training
2. Site-specific/on-the-job training

General Laser Safety Training

In the best interest of researchers, faculty, staff and students, the Auburn University is following the guidance of American National Standards Institute's (ANSI) Z136.1 -2014, American National Standard for Safe Use of Lasers. ANSI Z136.1-2014 provides reasonable and adequate guidance for the safe use of laser and laser systems that operate at wavelengths 180nm and 1000 µm. The Radiation Safety Office recommends that all groups using Class 3B and/or Class 4 lasers purchase their own current copy of ANSI Z136.1 Laser Safety Standard. A current copy of this standard is available on loan from the Radiation Safety Office.

The first part of **General Laser Safety Training** is an online course offered by the Department of Risk Management & Safety. In this initial laser safety-training module, the general laser safety principles will be covered. This includes engineering, administrative, personal protective laser safety controls, biological effects of laser radiation, common causes of laser accidents, non-beam hazards, and human behavioral factors as they relate to laser safety.

Site-Specific/On-The-Job Training

As the principal investigator of your laser and or laser system, you should be thinking of different and effective training methods that would introduce a new user to their new role in the laser lab. Hands-on-training has been shown to be effective and it provides an opportunity for new users to work at their own pace and have plenty of opportunities to ask questions while they are supervised. The result, hands-on-training helps comfort new users, provide experience, and set the standard to operate the laser safely.

Site-specific training for Class 3B and/or Class 4 lasers must include a thorough review by a senior, knowledgeable individual who recognizes all hazards associated with each laser that a person may operate and the protection methods that are required for each laser. All persons must be provided with adequate training so that they are sufficiently competent to operate the lasers independently and safely. All appropriate operational procedures (laser system startup, alignment, controls, shutdown etc.) must be covered in this training, including the necessary safety equipment and other safety related considerations.

It is the expectation to complete general laser safety training first before completing the hands-on-training. A **Certificate of Training Form** will be completed and submitted to the LSO indicating that this second component of training has been performed. Completion of all training must be documented. Remember, only qualified and trained users may operate Class 3B and/or Class 4 lasers. It is important to satisfy both training components as outlined in this section.

Control of Laser Areas

Laser safety control includes administrative controls and engineering controls. The combined use of both engineering and administrative control methods are thought to be the most effective in controlling hazards of laser radiation. Administrative controls are methods and instructions that promote laser safety in the laboratory. Such controls may include standard operating procedures, training, warning signs and labels, eye protection, and skin protection. Engineering controls are design features or devices applied to a laser system. It is generally considered the more effective of the two types of controls. Examples of engineering controls may include master switch control, key controls, beam enclosures, beam stops, beam tubes, beam barriers, beam dumps, interlocks, and shutters.

Access Control

All Class 3B and/or Class 4 lasers must be operated in a laser controlled area. It is necessary to secure these lasers against persons accidentally being exposed to beams, and be provided with a proper warning indication. In many facilities, the requirements for controlled laser areas have been interpreted to mean that the doors must be locked, or interlocked, and proper warning indication provided at the entrance to the area when the laser is operating, unless the area just inside the door is protected by a barrier. While locks can be used to secure the room, rapid egress from the area in the event of an emergency should not be impeded. Slide bolts and dead bolts are not acceptable locks since exit can be impeded.

The requirements for individual laser controlled areas must be determined by the LSO, however the minimum requirements for laser controlled areas can be listed as:

- Entryway controls to allow only authorized personnel or approved spectators to enter the laser control area. (Administrative controls are acceptable.)
- Laser safety eyewear available and used in accordance with the SOP for both Class 3 and/or Class 4 lasers.
- Beam control (barriers and beam blocks) to limit laser hazards within the controlled area.
- Written SOP for Class 3B and/or Class 4 lasers
- Training of operators of all Class 3B and/or Class 4 lasers.

Please notify the LSO before modifying any lasers, especially if the modifications warrant defeat of engineering safeguards. If this is a research laser that is under construction and engineering safeguards and/or interlocks are not utilized, this information must be noted in the comments of the attached **Class 3B and/or Class 4 Laser Registration Form**.

Warning Signs

The PI is responsible for posting signs and informing personnel of potential hazards related to laser(s) in PI's research areas. All signs must be conspicuously displayed at locations where they best serve to inform all lab personnel.

All rooms in which lasers are operated must be posted with permanent door-type laser warning signs, shown in figure 1, that include all information appropriate to the lasers operated within the rooms such as type of laser(s), wavelength(s), power output used, and minimum optical density for the laser wavelengths. Unauthorized personnel (e.g. guest, visitor, untrained personnel) may not enter rooms when lasers are in use unless accompanied by an authorized user. In particular, areas where Class 3B and/or Class 4 are used must be secured against persons accidentally being exposed to beams, and be provided with a proper warning indication. All windows, doorways, and portals should be covered or restricted to reduce transmitted laser levels below the maximum permissible exposure (MPE). Users must inspect the warning and access control devices periodically as a part of the overall safety program. Doorknob-type warning signs ("Do not enter", "Alignment in progress", "Laser in operation") must be temporarily posted in cases when persons intending to enter rooms or enter laser use areas need to be alerted regarding potentially enhanced hazards such as beam alignments. Please refer to figure 2 of examples of temporary postings.

Figure 1: Laser Warning Sign

Figure 2: Temporary Warning Signs

Please refer to **Instructions for Proper Posting** in obtaining appropriate signs for posting and advice on controlling laser areas. All types of laser warning signs are available at **Auburn University Door Sign Creator**.

In cases in which illuminated "laser-on" warning signs are present outside laser laboratories, be sure that there is signage clearly explaining the meaning of the lights. The lights should only be turned on during actual laser operation. Leaving an illuminated warning sign on unnecessarily allows users to become complacent. A continued lighted sign becomes part of the landscape that can be easily ignored. Keep in mind that at this time, illuminated "laser-on" signs are not required at the University. If you do decide to use lighted warning signs, signage must clearly explain the meaning of the lights.

Beam Alignment Procedures

Laser beam alignment requires working with an open beam and directing the beam toward a series of reflective or partially reflective surfaces, so that the beam follows a predetermined path. In research settings, serious laser accidents are known to occur during laser alignment. Appropriate steps must be taken to minimize the risk to beam injuries. Class 3B and/or Class 4 lasers must have corresponding alignment procedures included in **the Lab-Specific Laser Safety Procedures** section of the SOP and these procedures must be maintained by the laser at all times for reference.

Beam alignments may be internal or external. It can also be completed in three phases, pre-alignment, during alignment, and after the alignment. Internal alignment occur within the laser cavity and often place the worker at increased risk of electrical accidents as well as beam exposure. The need for internal alignment arises most often because of the problems associated with the beam mode or power. External alignments occur from the laser's end window to some terminal target (beam stop). In between these two locations may be a number of optical components arrayed in configurations that may be simple or complex. The need for external alignments arises because of requirements for an initial setup, reconfiguration, or replacement of components in the beam path.

Pre-alignment Procedures

- Make sure that only personnel who is authorized by the PI or laser supervisor are allowed in the laser lab during the alignment process.
- Post the "Laser Alignment in Progress" notice sign on the doorknob of the laser laboratory and lock the door. Examples are shown in figure 2 and 3.
- To reduce accidental reflections, remove all unnecessary reflective items from the optical table and your personnel (shiny tools, extra mirrors, jewelry, watch, plastic ID card, etc.).
- Wear appropriate laser protective eyewear with adequate optical density and clothing to the extent practicable during alignment. In some cases *(low power visible beam only)*, low optical density ***alignment eyewear*** can be worn. Contact Radiation Safety with any questions about protective eyewear. *M-rated eyewear is needed for lasers with pulses < 1 nsec*.
- Reduce the beam power as much as possible. Use a low-power (< 5 mW) visible beam laser like a He-Ne laser or a diode laser *(i.e., a laser pointer)* to align the optics, whenever possible.
- Make sure all materials needed for the alignment are readily available and that you have carefully thought through the alignment procedure in advance so there will be no surprises that could increase the likelihood of an accident.
- Isolate the beam from other areas of the laboratory using laser curtains, beam barriers, and beam stops. Enclose as much of the beam as you can to protect your eyes and skin.

Figure 3: Example of Appropriate Notice Sign

During the Alignment

- Use an indirect means of viewing the beam (beam detector card, infrared viewer scope, Zap-it paper, figure 3) except when aligning low power (<15 mW) visible beam lasers.
- Keep the beam on the plane of the optical table and well below normal sitting eye level. Never direct a beam upwardly or across a walkway!
- Do not leave a laser operating and unattended.
- Keep protective eyewear on during the entire process. Remember that special alignment eyewear is available for visible beam laser use (only safe for output power up to about 100 mW). Contact the LSO for information on this type of eyewear.

- For near infrared mode-locked and Q-switched laser, considered most dangerous, use a high degree of caution when aligning these lasers.
  - They are dangerous because of invisible or barely visible beams. Also they tend to have short pulse durations which translates to very high peak powers
  - M-rated eyewear is needed to absorb picosecond and femtosecond pulse laser radiation. Contact the LSO for ordering information

Figure 4: ZAP-IT Laser Alignment Paper

After the Alignment

- Replace the enclosures or other safety barriers that were removed for the alignment.
- Remove the alignment doorknob sign (see figure 2 for an example).
- Always store your protective eyewear near the lasers for which it is worn such that it will not get scratched or broken.

Protective Clothing and Eyewear

Laser safety is everyone's concern. The constant goal is establishing and maintaining a laser safe environment for users and guests. The most prominent safety concern with lasers is the possibility of damage from exposure to the laser beam. The primary affected sites are eyes and skin.

Protective Clothing

The hazards associated with skin exposure are of less importance than eye hazards. However, with the expanding use of higher power laser systems, the unprotected skin of personnel may be exposed to extremely hazardous levels of the beam power (beam hazard) if used in an unenclosed system design. There are also non-beam hazards that should be considered in order to protect the skin and eye.

- Remove personal jewelry. Watches, rings etc. act as reflectors. When entering a laser lab, remove anything that may pose a reflection hazard. This is to protect you and your co-workers.
- Gloves, lab coats, eye protection should be worn when preparing dyes and solvent for laser.
- It is recommended that any solution preparation must be done inside a fume hood.
- For hazardous gases and cryogenic materials, some may require special ventilation. When handling cryogenic materials it is appropriate to wear protective clothing and face shields.

Protective Eyewear

Engineering controls and administrative controls are the best way to control hazards. In terms of protection, protective eyewear is considered your last line of defense against laser hazards. Therefore, appropriate laser protective eyewear must be worn within the nominal hazard zone (NHZ) at all times when working with Class 3B and/or Class 4 lasers or laser systems and whenever there is a reasonable likelihood of exposure to a harmful level of laser radiation.

Laser protective eyewear is wavelength specific and proper selection is important, especially for optical density (OD). OD measures how much the lens of the laser safety glasses blocks the light that is transmitted from a particular wavelength. The higher the OD, the more laser light from that particular wavelength range is blocked. While a higher OD provides a greater level of protection, one of the drawbacks of a high OD lens is the decrease in visibility. Wearers tend to be discouraged and be not inclined to wear their protective eyewear with high OD. It is therefore necessary to determine the best-suited eyewear while working in the laser lab and not just buy the higher OD lens. Keep in mind that several companies have developed lens that is clear, but still provides a high OD. **Complete the Laser Safety Hazard Evaluation Form** and return it to LSO for assistance in selecting protective eyewear and determining the OD needed for adequate protection.

Eyewear must be maintained in good condition. Inspect your eyewear before each use, clean periodically and replace if necessary.

Vendor recommendations for eyewear selections and customer service can be found under Vendor Resources.

Common Causes of Laser Eye Injuries

- Unanticipated eye exposure during beam alignment
- Fatigue, carelessness, inappropriate shortcuts, or horseplay
- Upwardly-directed beam, beam at eye-level, or beam crossing walkways
- Eye protection not worn or the wrong eyewear worn
- Overconfidence; feeling of complacency or invincibility
- Beam not sufficiently enclosed or isolated
- Laser operator not sufficiently trained
- Laser use area not optically isolated from other lab areas and entryways
- Failure to follow SOP due to hurrying, impatience, etc.
- Manufacturer and laser user installed safety features removed or bypassed.

Audits

Upon installation, the LSO will do an initial audit of all Class 3B and/or Class 4 lasers to verify demonstration of compliance. Laser audits can also be requested and conducted on an as needed basis. Consequently, if there are changes in the initial configuration, number, or type of local components in the system, maintenance requiring the disassembly or removal of a local component in the system, and any time a visual inspection of the local components in the system reveals an abnormal condition, the LSO should be notified in order to conduct an audit.

After the initial LSO audit, it is expected that the PI will conduct an annual self-audit of each of their laser and laser system. The completed **Laser Safety Self-Audit/Inspection Form** must be submitted to the LSO shortly thereafter for review and potential follow-up inspections.

Non-Beam Hazards

Non-beam hazards (NBH) are all hazards arising from the presence of a laser system, excluding direct exposure of the eyes or skin to a laser beam. In some cases, non-beam hazards can be life threatening.

- **X-Rays** – Some of the high voltage systems with potentials greater than 30 kV may generate X-rays at significant dose rates. Plasma systems and ion sources operated at high voltages should also be checked for X-rays. High power (kilojoule) electron pumped Excimer lasers can generate significant X-ray levels (300 mrad per pulse at 15 feet). These devices must be checked by the Radiation Safety Office upon installation to ensure adequate shielding is included.
- **Plasma Radiation** – Materials can be made incandescent when exposed to laser radiations. These incandescent spots are very bright and can cause serious photochemical injuries to the eyes. The laser protective eyewear may not protect against such exposures. Whenever possible, view such spots through suitable filters such as TV cameras, etc.
- **Fire Hazards** – Class 4 visible and infrared beams with irradiances above 10 W/cm2 can ignite combustible beam enclosure materials. Keep flammables materials out of the beam line and maintain segregation between reactive reagents in the lab. Never use cardboard or paper for high power visible or infrared containment. For combustible and electrical fires, a fire extinguisher of the proper class (i.e. ABC or general purpose) must be readily accessible. Contact Auburn University Fire Safety for assistance.
- **Laser Generated Air Contaminants (LGAC)** – Air contaminates, produced by the interaction of the laser beam with the target material, can result in the production of hazardous materials. During surgical procedures, biohazardous aerosols containing blood-borne pathogens are created. The Occupational Safety and Health Association (OSHA) provides detailed information on biohazardous air contaminants produced during surgery. Fumes produced when laser radiation vaporizes or burns a target material whether metallic, organic or biological may be hazardous. Adequate local exhaust ventilation needs to be provided in the laser target zone. Contact LSO for assistance.
- **Chemical Hazards** – Many gases and all laser dyes and solvents used in some laser systems are highly toxic. Several laser dyes are carcinogenic. When dimethyl sulfoxide (DMSO) is the solvent, the dyes may be particularly hazardous if spilled on the skin because DMSO promotes absorption through the skin. If toxic chemicals are used in a laser system, Material Safety Datasheets (MSDS) must be reviewed prior to using them. MSDSs can be accessed through manufacturers' website. If the MSDS cannot be located, contact Auburn University Chemical Safety. Potential exposures to dyes and solvents are most likely to occur during solution preparation. During solution preparation, dye and solvent mixing should be done inside a chemical fume hood. Dye pumps and tubing/pipe connections should be designed to minimize leakage. Pumps and reservoirs should be set inside spill pans. Tubing/pipe systems should be pressure-tested prior to using dye solutions and periodically thereafter. Dye solutions can be corrosive. Stainless steel heat exchangers are recommended. Keep dye handling areas clean and segregated from other operations. Gas cylinders, dyes and solvents must be properly disposed of through Auburn University Chemical Waste Collection Program. Contact the Environmental Health and Safety for assistance.
- **Hazardous Gases and Cryogenic Materials –** Flammable gases, e.g., hydrogen, and oxygen tanks present significant hazards if proper handling, manifolding, and storage precautions are not followed. Other hazardous gases may also require special handling and ventilation. Gas cylinders must be properly anchored with metal linked chains, fastened at the top and near the base of

the tank to prevent falling. Such tanks can become high velocity projectiles and can cause significant property damage and injuries, contact Auburn University Lab Safety for assistance. A number of laser systems utilize toxic gases (e.g., HF). These gases must be contained in approved ventilation and manifold systems. Contact LSO for information on approved systems. Wear appropriate protective clothing and face shields when handling large quantities of liquid nitrogen (LN) or other cryogenic materials. The normal moisture and oils present on the skin will protect against a few drops of LN spilled on the skin, but large quantities can cause severe frostbite. LN and inert gases can displace air in a room or confined area and cause asphyxiation. Good ventilation is required in areas where these gases and cryogenic liquids are used. Open dewars of liquid nitrogen can condense oxygen from the room air and cause fire or explosion hazards if the oxygen contacts a fuel.

- **Electrical Hazards** – Most laser systems involve high potential, high current power supplies. The most serious accidents with lasers have been electrocutions. There have been several electrocution fatalities related to lasers, nationwide. Only qualified personnel may perform all internal maintenance to the laser and more than one user must be present when performing said maintenance. Make sure that high voltage systems are off and locked out, and especially that high-energy capacitors are fully discharged prior to working on a system. Beware that capacitors may have their charges restored after initial discharge. Systems should be shorted during repair or maintenance procedures. The discharge of large capacitors requires proper equipment and procedures because significant levels of stored energy can be released as heat or mechanical energy. Class 3B and/or Class 4 lasers should have a separate circuit and local cut-off switch (breaker) for the circuit. Label and post electrical high voltage hazards and switches. Clearly identify the main switches to cut-off power. Before working on a laser, de-energize the machine. Keep cooling water connections away from main power and high voltage outlets and contacts. Use double hose clamps on cooling water hoses. Inspect cooling water hoses and connections and power cables and connectors periodically as part of a regular equipment inspection. Contact Auburn University Electrical Shop for assistance in electrical service within buildings.
- **UV Lasers –** Since UV radiation scatters easily from many surfaces, and exposure to UV radiation can cause cancer and it is important to contain UV radiation as much as possible. Wear gloves, (when hands are near the beam) long sleeve lab coats, and face and eye protection against UV radiation exposure. Avoid putting hands into the invisible beam (use fluorescent screens to define the beam). When intense UV radiation is absorbed in air, ozone will be produced and proper ventilation may be needed. Contact LSO for assistance on ozone concerns and UV radiation hazards.
- **Noise** – Certain lasers and associated electrical devices can generate painful and unpleasant noises at high frequency or repetitive rate that are harmful to the ears. Noise levels from certain lasers, and their work environment, may be of such intensity that noise control may be necessary.

Human Factors in Laser Safety

Supervisor Judgement

An intangible but critically important laser safety issue has to do with the mental readiness of laser operators to perform their studies. If a graduate student were awake the entire night studying for a final examination, that person would be a poor choice to operate a hazardous open-beam laser the following day. If a technician enters the laboratory very upset because another vehicle just sideswiped his new car, he would likely not be in a proper state of mind to perform operations in which a high level of concentration is needed. If a laser technician appears to have a health condition such that he/she may be on a drowsiness-inducing medication, then it would be best to have him/her do less hazardous work. The common thread among these examples is that not all persons who show up at a laser laboratory are fit for duty. It is up to the judgment of the Principal Investigator or laser supervisor to prevent those who are temporarily impaired from operating hazardous lasers and possibly injuring themselves.

Ergonomics

There may be ergonomic hazards associated with the operation, maintenance, or service of the laser system. The ergonomic hazards such as awkward postures, poor workstation layout, worker machine interface, manual handling techniques, and area illumination could contribute to improper actions if not addresses. Painful arm, hand, and wrist injuries (e.g. carpal tunnel syndrome) may result from repetitive motions occurring during the use of some laser products. Ergo-ophthalmological issues such as glare, startle reactions, afterimages and temporary flash blindness have been reported in the laser environment as distractions that lead to other primary or secondary effects of a more serious biological nature.

Limited Work Space

There is limited workspace or area in many laser system installations. Such limited workspace can present a problem while working near or around mechanical setup or high voltage. There should be sufficient room for personnel to turn around and maneuver freely. This issue is further compounded when more than one type of laser is being operated at the same time. The presence of wires and cables on the floor of limited work areas can create trip and slip hazards. Laser areas can pose hazard to laser workers due to obstacles, ambient lighting, confined workplaces, indoor temperature and humidity.

Emergency Procedures

In the event of a laser accident, below provides an outline that can be followed. Keep in mind that supervisors of laser areas should create their own emergency procedure that is unique to the lab and ensure that other users are fully aware of the procedure.

1. Turn off the laser involved in the accident immediately and unplug it. Post a “Do not use!” sign on the laser to ensure it is not used again until it can be determined that it is safe.
2. In case of injury:
   - If the injury is life-threatening (electrocution), ***call 911 immediately***.
   - Keep the injured person calm. If an eye injury is suspected, keep the person in an upright position.
   - Make sure the injured person receives immediate medical treatment if the injury is serious – injured persons need to be seen by a doctor as soon as possible.
   - Arrange for transportation of the seriously injured person to a medical facility. The victim might be in shock or have impaired vision so self-transportation is contraindicated.
3. If the Principal Investigator responsible for the laser involved is not present at the time of the injury, notify the Principal Investigator first then contact LSO as soon as possible.

Lab-specific Laser Safety Procedures

Please add below any appropriate safety-related procedures specific to your laser. Include instruction on laser specific guidelines, special precautions, unusual conditions as well as login, system startup, routine maintenance, shutdown, logout and detailed alignment procedures, and including all safety-related steps and any data recording procedures that are related to radiation safety:

Vendor Resources

The protective eyewear vendors below have good eyewear selections and excellent customer service. They supply standard laser eyewear and certified M-rated eyewear and they give discounts on eyewear to educational institutions like Auburn University. This list is provided as a reference only and should not be considered as an endorsement of any particular company or product, by Auburn University.

1. NoIR Laser Company
   Address: P.O. Box 159
   South Lyon, MI 48178
   Phone: 800-393-5565
   Fax: 651-357-1830
   Web: www.noirlaser.com

2. Laservision
   Address: 595 Phalen Blvd.
   St. Paul, MN 55101
   Phone: 800-521-9746
   Fax: 734-769-1708
   Web: www.lasersafety.com

3. Mallory/California Safety & Supply Co.
   Address: 44340 Osgood Road
   Fremont, CA 94539
   Phone: 408-727-8530
   Web: www.calsafety.com

4. Kentek Corporation
   Address: 1 Elm Street
   Pittsfield, NH 03263
   Phone: 800-432-2323
   Web: www.kenteklaserstore.com

5. Newport Corporation
   Address: 1791 Deere Avenue
   Irvine, CA 92606
   Phone: 949-863-3144
   Web: www.newport.com

Forms

Class 3B and/or Class 4 Laser Registration Form

Laser Safety Hazard Evaluation Form

Laser Safety Self-Audit/Inspection Form

The Certificate of Training

Instructions for Proper Posting

The Alignment Procedures

CLASS 3B AND/OR CLASS 4 LASER REGISTRATION FORM

Principal investigator:		**Date:**
Department:		
Phone number:		**Email:**
Lab. contact:		**Email:**
1- PERSONNEL WHO USE LASER SYSTEMS		
Name & last name	**AU affiliation (student or staff)**	
2- LASER SYSTEM INFORMATION		
System location (building & room #)**:**		
Manufacturer:		
Model:		
Serial number:		
Class (3B or 4):		
Type (i.e., Argon-ion, He-Ne, CO2, Nd:YAG):		
Mode of operation : Continuous Wave (CW), Single Pulse, Repetitive Pulse (more than one might apply)		
Beam diameter at aperture (mm):		
Beam divergence (mrad):		
3- LASER PARAMETERS		
Continuous Wave Laser Information		
Wavelength(s) (micron or nanometer):		
Average power (Watts):		
Energy of the exposure (Joules):		

Single Pulse Laser Information	
Wavelength(s) (micron or nanometer):	
Energy per pulse (Joules):	
Peak power (Watts):	
Duration of the laser pulse (seconds):	
Repetitive Pulse Laser Information	
Wavelength(s) (micron or nanometer):	
Energy per pulse (Joules):	
Peak power (Watts):	
Average power (Watts):	
Duration for one pulse of the pulse train (seconds):	
Pulse repetition frequency (Hertz): (Frequency of repetitive pulse laser)	
Total exposure duration (seconds): (The total time that a user might be exposed to the laser output. If not known, ANSI default exposure durations will be used)	

Check all items that apply:			
Use of Cryogens	☐	**Invisible Beam**	☐
Use of Compressed Gases	☐	**Direct Viewing of the Laser Beam**	☐
High Noise Levels	☐	**Beam Focusing Optics**	☐
High Voltage Power Supplies	☐	**Fiber Optics (Single or Multiple Mode Fiber)**	☐
High Voltage (>30 kVp)	☐	**Exposed Beam Paths**	☐
Dye Laser	☐	**Frequency Doubling Crystal**	☐
Tunable Laser	☐	**Laser Cutting / Welding**	☐

Is the laser(s) modified? Does the modifications warrant defeat of engineering safeguards? Is this a research laser under construction and engineering safeguards and/or interlocks are not utilized?
COMMENTS:

Purpose of laser use (i.e. holography, alignment, spectroscopy, surgery, veterinary use, etc.), provide sufficient detail:

LASER SAFETY HAZARD EVALUATION FORM

Principal Investigator:		**Date:**
Department:	**College/School:**	

LASER DATA				
	Laser 1	**Laser 2**	**Laser 3**	**Laser 4**
Type of laser (i.e., Nd: YAG, Argon, HeNe, etc.)				
Class (IIIB or IV)				
Wavelength (micron or nanometer)				
Mode of operation (Continuous Wave, Single Pulse, Repetitive Pulse) (*more than one might apply*)				
Continuous Wave laser: Average Power or Energy (W or J)				
Single or Repetitive Pulse lasers: Average/Peak Power, or Energy per pulse (W or J)				
Pulse duration (seconds)				
Pulse repetition rate (Hertz) (Frequency of repetitive pulse laser)				
Exposure duration(s) (The total time that a laser user may be exposed to the laser output. If not known, ANSI default exposure durations will be used)				
Laser safety eyewear currently available (Yes or No?) (if yes, provide details below)				
Eyewear manufacturer				
Manufacturer/model				
Eyewear rated Optical Density (OD); (i.e. 532-585)				
Wavelength range for rated OD (nm)				
Visible Light Transmission (VLT) (%)				
Optical Density (OD)*				
Nominal Hazard Zone (NHZ)*				

**** To be determined by Radiation Safety***

Return this form to Laser Safety Officer, (kucukse@auburn.edu)
or call 334-844-6238 for more information.

Add Comments:

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Certification: (to be completed by each person submitting the information requested on this form)

By signing this form, I certify that all information on this form and additional supporting information submitted with this form are accurate and complete to the best of my knowledge.

Signature: ______________________________ Date: ____________________

Laser Safety Self Audit/Inspection Form

This form must be completed and submitted to the Laser Safety Officer (LSO) once a year to prepare for the annual laser safety inspections. Please maintain a copy of completed form for your lab records.
Contact LSO at kucukse@auburn.edu or call at 334-844-6238 for further questions.

Laser Owner/PI	E-mail	Building	Room
Class/Type	**Model**	**Serial Number**	**Manufacturer**

Please indicate YES if complaint, NO if not complaint, N/A if not

Laser Posting, Labelling and Security Measures	YES	NO	NA	Comment
Entrances properly posted with appropriate warning signs				
Lasers properly labeled				
Room and laser security adequate				
Only authorized personnel permitted in laser area				
Door, blocking barrier, curtain, etc. at all entryways				
Entryway interlock system present				
Entryway interlock system functioning				
Laser warning indicator/light outside room				
Laser Unit Safety Controls	**YES**	**NO**	**NA**	**Comment**
Protective housing in place				
Interlock on housing				
Interlock on housing functioning				
Access panel for service				
Beam shutter/attenuator present				
Control measures to prevent unauthorized activation				
Key control				
Password protected computer access				
Laser activation warning system in place				
Remote interlock connector				
In-house service for laser				
Company service for laser				
Engineering Safety Controls	**YES**	**NO**	**NA**	**Comment**
Laser secured to table				
Laser optics secured to prevent stray beams				
Exposed beam path not at normal eye level				
Upward directed beams				
Enclosed beam path				
Limited open beam path				
Totally open beam path				

Beam barriers in place				
Appropriate barrier material used				
Beam stops in place				
Microscope used for viewing (example – TIRF)				
Microscope eye pieces filtered				
Remote viewing of beam (example – CDD camera)				
Beam focused or enlarged				
Beam intensity reduced through filtration (ND filters)				
Fiber optics used				
Reflective materials kept out of beam path				
Physical evidence of stray beams				
Class 4 diffuse reflective hazards minimized				
Administrative Safety Control Measures	**YES**	**NO**	**NA**	**Comment**
Laser is registered and inventoried with the Laser Safety Officer at Auburn University				
Written Standard Operating Procedures (SOP) available				
SOP up-to date				
SOP read and signed by PI and users				
Written alignment procedures included in SOP				
Emergency procedures included in SOP				
All laser users have completed Auburn University online Laser Safety training				
All laser users have completed on-the-job/hands-on hazard specific laser safety training offered by PI				
Training records has been kept and updated				
Appropriate action taken for spectator/visitor control				
All lab personnel know how to access the Laser Safety Manual on Risk Management and Safety website				
Any homebuilt or modified laser has been classified				
Log is kept showing laser use, service and maintenance				
Users clearly identified in log				
Personal Protective Equipment	**YES**	**NO**	**NA**	**Comment**
Proper laser eye protection available				
OD and wavelength are correct for use				
Enough eye protection for all users				
Proper skin protection available for UV lasers				
Gloves and/or lab coats or UV block				
No loose clothing				
Non-Beam Hazards	**YES**	**NO**	**NA**	**Comment**
Toxic laser media in use				
Hazardous laser media stored properly				
Fume hood for dye mixing				
Proper disposal of chemical wastes				

Cryogens in use				
Compressed gas in use				
Gas cylinders properly restrained				
Laser generated air contaminants (LGAC) produced				
High voltage power hazard				
Electrical panels unobstructed				
Optical table/equipment grounded				
Explosion hazard				
Collateral and plasma radiation hazard				
Fire hazard				
Noise/vibration hazard				
Good housekeeping				

Additional Comments:
____
____
____
____

Certification: (to be completed by each person submitting the information requested on this form)

By signing this form, I certify that all information on this form and additional supporting information submitted with this form are true and complete to the best of my knowledge.

Signature: ____________________ Date: ____________________

Auburn University

Certificate of Training for Use of Lasers

____
Name of Laser User

____
Name of Instructor (Principal Investigator or Designee)

- ☐ *Beam and non-beam laser hazards and precautions*
- ☐ *Function and meaning of safety controls, indicators, and interlocks*
- ☐ *Standard Operating Procedures (SOP) and experiment protocols*
- ☐ *Knowledge of how to access Laser Safety Manual on Risk Management and Safety website*
- ☐ *Maintenance of required records*
- ☐ *Emergency procedures*
- ☐ ____
- ☐ ____

We certify that the laser user named above has been trained and instructed in the proper and safe use of laser and laser systems in my research areas. The extent of this training and instruction is such that we are confident that the laser user is qualified to perform the operating and safety procedures. All of the topics checked above have been discussed.

__________________________	__________________________
Signature of Laser User	*Signature of Instructor/Date*

When completed, return this form to:

Laser Safety Officer @ kucukse@auburn.edu
1161 W. Samford Ave
RMS Building 9

Information for Proper Posting & Laser Area Sign Templates

All signs must be conspicuously displayed at locations where they best serve to inform all.

Any area that contains a **Class 3R, Class 3B and Class 4** laser or laser system must be posted with the appropriate sign described below. The exterior boundary of a **temporary laser controlled** area must also be posted with a Notice sign as described below.

The purpose of a laser area warning sign is to convey a rapid visual hazard-alerting message that:

a) Warns of the presence of a laser hazard in the area
b) Indicates specific policy in effect relative to laser controls
c) Indicates the severity of the hazard (e.g., class of laser, NHZ extent)
d) Instructs appropriate action(s) to take to avoid the hazard (e.g., eyewear requirements)

The signal words have the following meanings:

- **"DANGER"** indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme conditions. The signal word "Danger" indicates that death or serious injury will occur if necessary control measures are not implemented to mitigate the hazards within the laser controlled area. This signal word is designated to Class 4 lasers with high (e.g., multi-kilowatt) output power or pulse energies with exposed beams.

- **"WARNING"** indicates an imminently hazardous situation that, if not avoided, could result in death or serious injury. The signal word "Warning" shall be used on laser area warning signs associated with lasers and laser systems whose output exceeds the applicable MPE for irradiance, including all Class 3B and most Class 4 lasers and laser systems.

- **"CAUTION"** indicates a hazardous situation that, if not avoided, could result in minor or moderate injury. It may also be used without the safety alert symbol as an alternative to "NOTICE." The signal word "Caution" shall be used with all signs and labels associated with Class 2 and Class 2M lasers and laser systems that do not exceed the applicable MPE for irradiance.

- **"NOTICE"** is the preferred signal word to address practices not related to personal injury.

Message Panel Information

Adequate space is available within each templates message panel to allow for the inclusion of pertinent information. Add the addition information to the applicable template below:

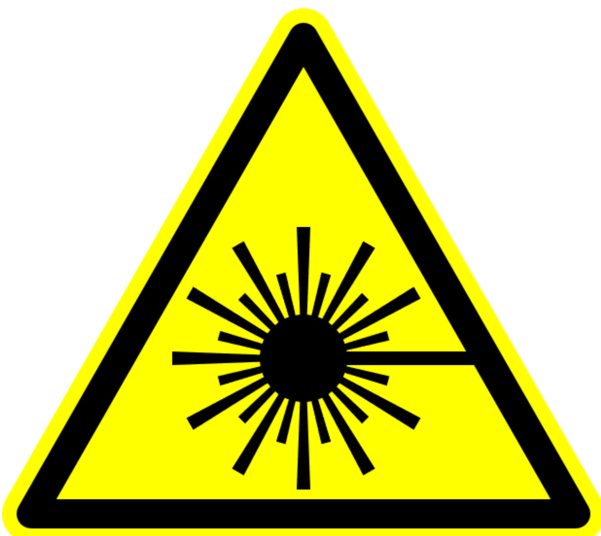
a) The hazard class of the laser controlled area.
b) Special precautionary instructions or protective action that may be applicable. For example:

    - Laser Eye Protection Required
    - Invisible Laser Radiation
    - Do Not Enter When Light is Illuminated
    - Restricted Area, Authorized Personnel Only

c) The highest hazard class of the laser or lasers within the laser controlled area.
d) Additional information such as follows:

    - The optical density for eye wear to be worn within the area – include the most common for a tunable laser/laser system
    - Type of Laser(s)
    - Wavelength(s) – List most common for a tunable laser/laser system
    - Max Power/Energy of Laser – List most common for a tunable laser/laser system

CAUTION



Class 2 Laser in Use

Do not stare into beam or view directly with optical instruments.

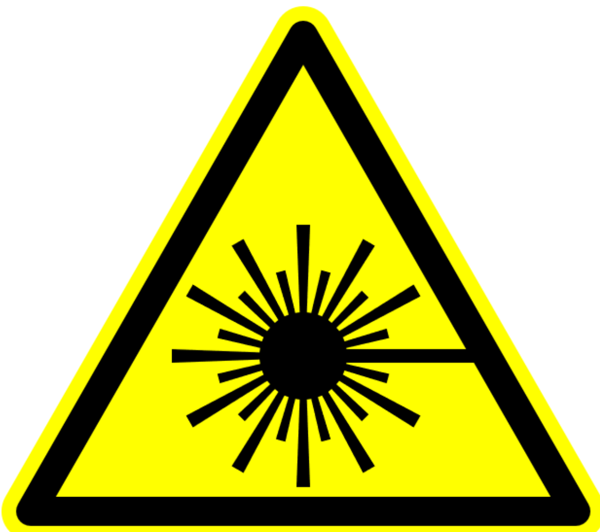
Laser Type:

Wavelength (nm):

Power/Energy:

Emergency Contact:

CAUTION



Class 2M Laser In Use

Do not stare into beam or view directly with optical instruments.

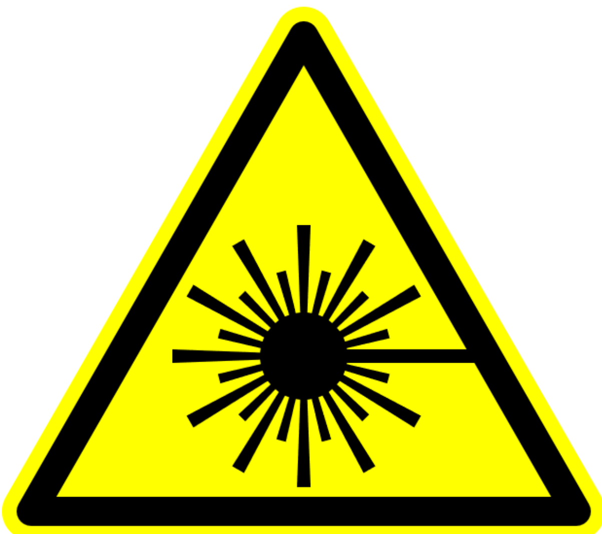
Laser Type:

Wavelength(nm):

Power/Energy:

Emergency Contact:

CAUTION



Class 3R Laser In Use

Do not stare into beam or view directly with optical instruments.

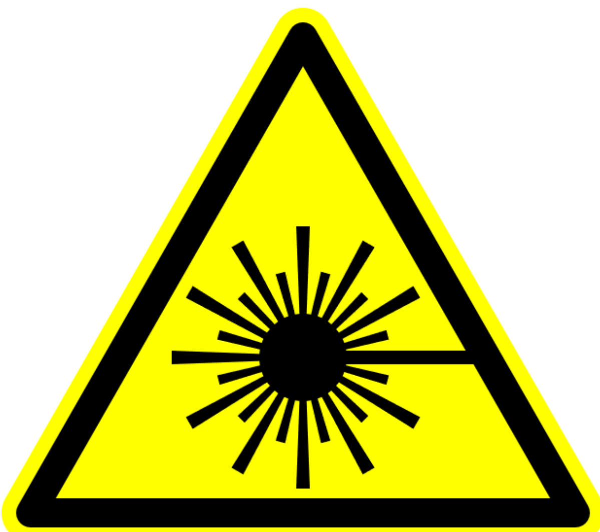
Laser Type:

Wavelength (nm):

Power/Energy:

Emergency Contact:

WARNING



Class 3B Laser Controlled Area

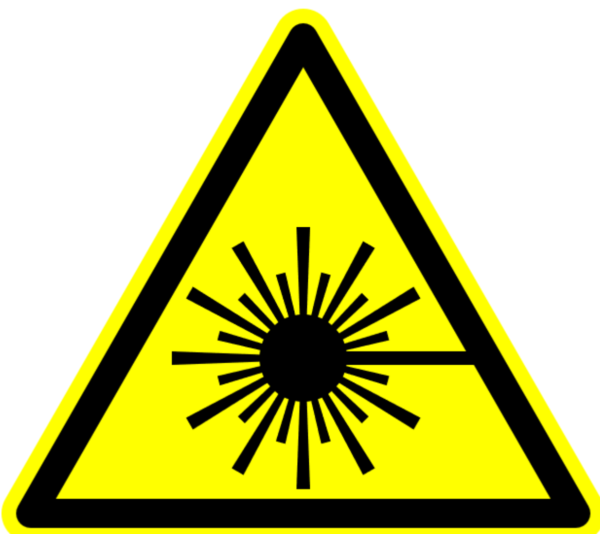
Avoid eye or skin exposure to direct or scattered radiation.

Do Not Enter When Light is Illuminated

Laser Eye Protection: OD ≥
Laser Type:
Wavelength(nm):
Power/Energy:

Emergency Contact:

WARNING



Class 4 Laser Controlled Area

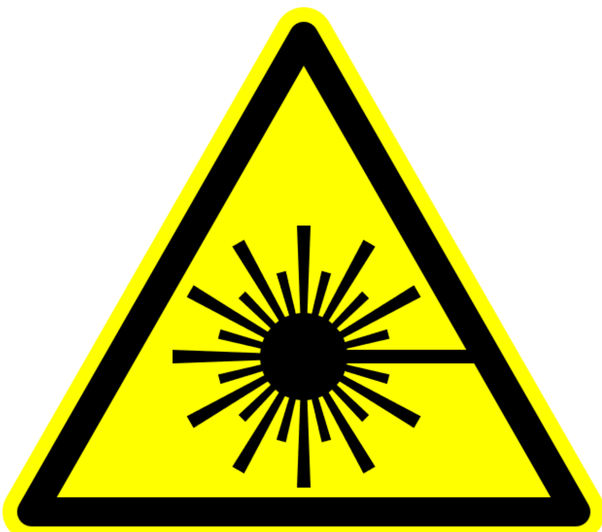
Avoid eye or skin exposure to direct or scattered radiation.

Do Not Enter When Light is Illuminated

Laser Eye Protection: OD ≥
Laser Type:
Wavelength (nm):
Power/Energy:

Emergency Contact:

DANGER



Class 4 Laser Controlled Area

Avoid eye or skin exposure to direct or scattered radiation.

Do Not Enter When Light is Illuminated

Laser Eye Protection: OD ≥
Laser Type:
Wavelength (nm):
Power/Energy:

Emergency Contact:

NOTICE

Emergency Contact:

Alignment Guidelines

In research settings, serious laser accidents are known to occur during laser alignment. Be careful!

Appropriate steps must be taken to minimize the risk to beam injuries occurring during alignment procedures. Class 3B and Class 4 lasers must have corresponding alignment procedures written and maintained with the laser for reference.

Alignments should be done only by those who have received laser safety training. It is best to perform alignments with another trained person. Review all procedures before attempting the alignment. Make sure that all warning signs, lights and locks are operating.

At alignment conclusion, normal laser hazard controls must be restored. Controls set back in place include replacing all enclosures, covers, beam blocks, barriers and checking affected interlocks for proper operation.

Alignment Procedures for Class 3B and Class 4 Lasers

Pre-alignment Procedures

1. Exclude unnecessary personnel from the laser area during alignment.
2. Post the "Laser Alignment in Progress" notice sign on the doorknob to the laser laboratory and lock the door.
3. Housekeeping is paramount. The work area and optical table should be free of objects or surfaces that could reflect the light. Remove any jewelry, watches, rings (or cover rings with tape), remove objects in shirt pockets, and remove id badges. Make sure any reflective surfaces in the area are blocked or covered. Remove any unnecessary equipment, tools and combustible materials.
4. Make sure all materials needed for the alignment are readily available and that you have carefully thought through the alignment procedure in advance so there will be no surprises that could increase the likelihood of an accident.
5. Wear protective eyewear and clothing to the extent practicable. Use special alignment eyewear when circumstances (e.g. wavelength, power, etc.) permit their use. In some cases (low power visible beam only), low optical density alignment eyewear can be worn. M-rated eyewear is needed for lasers with pulses < 1 nsec. Alternate means of viewing the beam such as CCD and web cameras should be considered before allowing the use of alignment eyewear.

6. Whenever possible, use low-power (< 5 mW) visible lasers for path simulation of higher-power visible or invisible lasers like a He-Ne laser or a diode laser (i.e., a laser pointer) to align the optics.
7. Isolate the beam from other areas of the laboratory using laser curtains, beam barriers, and beam stops. Enclose as much of the beam as you can to protect your eyes and skin.

During the Alignment

8. Keep protective eyewear on during the entire alignment process. Remember that special alignment eyewear is available for visible beam laser use (only safe for output power up to about 100 mW).

9. Use beam display devices such as image converter viewers or use an indirect means of viewing the beam (beam detector card, infrared viewer scope, Zap-it paper) to locate beams except when aligning low power (<15 mW) visible beam lasers.

10. Keep the beam on the plane of the optical table and well below normal sitting eye level. Never direct a beam upwardly or across a walkway!

11. Perform alignment tasks that use high-power lasers, at the lowest possible power level. Pulsed lasers are aligned with single pulses if possible. If the laser is Q-switched, turn off the Q-switch and use low power or CW.

12. For near infrared mode-locked and Q-switched laser, considered most dangerous, use a high degree of caution when aligning these lasers.

    - They are dangerous because of invisible or barely visible beams. Also they tend to have short pulse durations which translates to very high peak powers

    - M-rated eyewear is needed to absorb picosecond and femtosecond pulse laser radiation. Contact the LSO for ordering information

13. Use a shutter or beam block to block high-power beams at their source except when actually needed during the alignment process.

14. Use a laser-rated beam block to terminate high-power beams down range of the optics being aligned.

15. Use beam blocks and/or laser protective barriers in conditions where alignment beams could stray into areas with uninvolved personnel.

16. Place beam blocks behind optics (e.g., turning mirrors) to terminate beams that might miss mirrors during alignment.

17. Locate and block all stray reflections before proceeding to the next optical component or section.
18. Be sure all beams and reflections are properly terminated before high-power operation.
    - Whoever moves or places an optical component on an optical table (or in a beam path) is responsible for identifying and terminating each and every stray beam coming from that component (meaning reflections, diffuse or specular).
19. There must be no intentional intrabeam viewing with the eye.

After the Alignment

20. Replace the enclosures or other safety barriers that were removed for the alignment.
21. Remove the alignment doorknob sign.
22. Always store your protective eyewear near the lasers for which it is worn such that it will not get scratched or broken.

Procedures derived from: ANSI Z136.1